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TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

Volume 22

1989

HUBERT C. SKINNER

and

EMILY H. VOKES

Editors

TULANE UNIVERSITY OF LOUISIANA
New Orleans

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VICTOR A. ZULLO[1]

and

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I. ABSTRACT

The geologic range of *Actinobalanus* Moroni is extended back to the lower Miocene with the discovery of two new species: *A. collinsi* from the Berchem Formation of Belgium, and *A. floridanus* from the Chipola Formation of Florida. The Chipola species is the first record for the genus outside of western Europe. Of the seven species previously included in *Actinobalanus,* only three, the type species *A. actinomorphus* (Moroni) from the Pliocene and lower Pleistocene of Italy and Sicily, *A. bisulcatus* (Darwin) from the Pliocene of western Europe and *A. dolosus* (Darwin) from the Pleistocene of England are retained in the genus. *Balanus pantanelli* Alessandri and *B. stellaris* (Brocchi) are returned to the genus *Balanus* Da Costa. *Balanus inclusus* Darwin and *Actinobalanus darraghi* Buckeridge are tentatively assigned to *Conopea* Say.

II. INTRODUCTION

Actinobalanus was established as a subgenus of *Balanus* Da Costa by Moroni (1967) for solid-walled barnacles from the Pliocene and Pleistocene of western Europe that possessed a tubiferous basis and simple, non-denticulate, parietal septa. Moroni included *Balanus actinomorphus* Moroni, *B. bisulcatus* Darwin, *B. dolosus* Darwin, and *B. inclusus* Darwin in *Actinobalanus.* Newman and Ross (1976), in their monograph on the Balanomorpha, raised *Actinobalanus* to generic rank, assigned it to the family Archaeobalanidae, and added *B. pantanelli* Alessandri and *B. stellaris* (Brocchi), together with *B. corrugatus* Darwin as a subjective synonym of *B. stellaris* (following Alessandri, 1906). No reasons were given by Newman and Ross for the addition of these species, but as all three have tubiferous, bilamellar parietes, they are excluded from *Actinobalanus.* Therefore, the retention of *B. pantanelli, B. stellaris* and *B. corrugatus* in the genus *Balanus* of the family Balanidae is appropriate.

Balanus inclusus, although possessing solid, monolamellar parietes and a tubiferous basis, differs from the three other species originally assigned to *Actinobalanus* in two significant features. The radii of *B. inclusus* are clearly transparietal (*i.e.,* a radius that extends across the ala to the adjacent paries throughout

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most of its length, and having the sutural edge denticulate) rather than disparietal (*i.e.*, a radius not extending across the ala to the adjacent paries except at the base of the shell wall, and lacking septate sutural edges), and the scutum lacks an adductor ridge. The total combination of characters seen in *B. inclusus*, including the convexity of the scutal articular ridge, the presence of a small, deep, scutal depressor muscle pit, and the basal truncation of the parallel-sided tergal spur, suggests assignment to the genus *Conopea* Say.

Most recently, Buckeridge (1983) attributed a new species with solid parietes and a tubiferous basis from the upper Miocene and lower Pliocene of Victoria, Australia to *Actinobalanus*. If *A. darraghi* Buckeridge were indeed representative of the genus, it would signal a significant extension in geographic range for *Actinobalanus*. However, like *Conopea inclusa*, *A. darraghi* has transparietal radii and lacks a scutal adductor ridge, thus removing it from the genus *Actinobalanus*. Generic reassignment of "*A.*" *darraghi* cannot be determined from the published description and illustrations, but the globulo-conic shell and the form of the scutum of "*A.*" *darraghi* are suggestive of *Conopea*.

Previous reports of *Actinobalanus bisulcatus* and *A. dolosus* by Alessandri (1907, 1922), Lecointre (1910), Withers (1953) and Davadie (1963) from Miocene or Paleogene deposits cannot be verified. These records are either in lists unsubstantiated by descriptions and illustrations, or are based on shells lacking distinguishing features. The new lower Miocene species described herein, one from the Burdigalian Edegem sands of the Berchem Formation in Belgium, the other from the Burdigalian Chipola Formation in northern Florida, are the first undoubted pre-Pliocene records for the genus. The North American species provides the first undoubted evidence of the presence of *Actinobalanus* outside of western Europe.

III. SYSTEMATIC PALEONTOLOGY

Suborder BALANOMORPHA Pilsbry, 1916

Superfamily BALANOIDEA Leach, 1817, *sensu* Newman and Ross, 1976

Family ARCHAEOBALANIDAE Newman and Ross, 1976

Subfamily ARCHAEOBALANINAE Newman and Ross, 1976

Genus ACTINOBALANUS Moroni 1967

Actinobalanus MORONI, 1967, p. 919, 926; NEWMAN, ZULLO and WITHERS, 1969, p. R628; NEWMAN and ROSS, 1976, p. 49.

Type species: *Balanus* (*Hesperibalanus*?) *actinomorphus* Moroni; original designation.

Emended diagnosis: Parietes monolamellar, solid, smooth or costate; parietal ribs not denticulate; radii solid, narrow to broad, disparietal or paraparietal (fine striations present on sutural edges of *A. dolosus*); basis calcareous, tubiferous; interior of scutum and tergum usually rugose; scutal adductor ridge present; no callus between scutal adductor and articular ridges; scutal depressor muscle pit absent or small and deep, without crests; tergal spur narrow to broad, short, usually acuminate, basally rounded or subtruncate, with spur fasciole.

Geologic and geographic distribution: Miocene - middle Pleistocene, western Europe; lower Miocene, Florida.

Discussion: Actinobalanus can be distinguished from most solidobalanid genera by its possession of a well-defined scutal adductor ridge. Among those genera possessing an adductor ridge, *Actinobalanus* is most similar to *Lophobalanus* Zullo, 1984, differing in possessing a tubiferous basis and internally rugose opercular plates. It differs from *Hesperibalanus* in having a tubiferous basis, and in lacking transparietal radii and a ridged callus between the scutal adductor and articular ridges. *Actinobalanus* is distinguished from *Notobalanus* Ross, 1976 by the absence of crests in the scutal depressor muscle pit and of irregular ribs at the base of the shell wall.

ACTINOBALANUS ACTINOMORPHUS (Moroni, 1952)

Balanus (*Hesperibalanus*?) *actinomorphus* MORONI, 1952, p. 73, pl. 1, figs. 1-4, 7-8, pl. 2, figs. 4-7.

?*Balanus bisulcatus* Darwin. WITHERS, 1953, p. 62 (Zanclean White Limestone, Sicily).

Balanus (Actinobalanus) actinomorphus Moroni. MORONI, 1967, p. 923, text figs. 3-4, pl. 70, figs. 1-2a.

Actinobalanus actinomorphus (Moroni). NEWMAN and ROSS, 1976, p. 49.

Holotype: No. 115, Cirriped Collection, University of Bologna.

Type locality: Sabbie gialle, near Fauglia, Colline pisane, Tuscany, Italy.

Emended diagnosis: Parietes markedly costate or occasionally smooth; radii narrow, disparietal; scutum without external radial ornament and low, indistinct, broadly spaced growth ridges; basal margin of scutum nearly three-fourths length of occludent margin; scutal adductor ridge very short, less than one-fifth length of occludent margin, centrally located; scutal articular ridge reflexed, extending well beyond tergal margin; tergum triangular, with straight scutal margin; carinal margin without upturned growth ridges; tergal spur short, subacuminate, narrow, occupying about one-third width of basal margin; juncture of basal spur and carinal side of basal margin gently arcuate.

Geologic and geographic distribution: Pliocene - lower Pleistocene, Italy and Sicily. Lower Pliocene: Contrada Cicio, near Partana (Trapani), Sicily. Lower Pleistocene (lower Calabrian): Sabbie gialle, Colline pisane, vicinity of Marti, Montecastello, Lorenzana, and Fauglia (type locality), Tuscany, central Italy; sabbie calcarifere a *Flabellipecten alessii*, western shore of the Lago di Pergusa, near Piazza Armerina, Sicily.

Discussion: Actinobalanus actinomorphus is most readily distinguished from *A. bisulcatus* and *A. dolosus* by its scutum, which has a much shorter adductor ridge and a highly reflexed articular ridge extending well beyond the tergal margin. Its scutum differs additionally from that of *B. bisulcatus* in lacking external radial furrows. *Actinobalanus actinomorphus* differs from the new Belgian Miocene species in having much thinner opercular plates, and in lacking a broad shelf developed on the scutal margin of the tergum. The new Florida Miocene species is most similar to *A. actinomorphus*, but can be distinguished by its usually smooth rather than usually costate shell, its narrower scutum with a longer adductor ridge, and the carinal margin of the tergum which bears upturned growth ridges. The record of *A. bisulcatus* published by Withers (1953) in a list of species from the Zanclean (lower Pliocene) White Limestone of Sicily probably can be referred to *A. actinomorphus*.

ACTINOBALANUS BISCULATUS (Darwin, 1854)
Plate 1, figs. 1-4

Balanus bisulcatus DARWIN, 1854a, p. 293, pl. 8, figs. 6a-c; 1854b, p. 26, tab. 2, figs. 2a-b, e-h.

Balanus bisulcatus var. *plicatus* DARWIN, 1854a, p. 293; 1854b, p. 26, tab. 2, figs. 2c, ?2d.

Balanus (Armatobalanus) bisulcatus Darwin. DAVADIE, 1963, p. 74, pl. 41, fig. 6; pl. 42, figs. 1-2; pl. 47, figs. la-2b.

Balanus (Armatobalanus) bisulcatus plicatus Darwin. DAVADIE, 1963, p. 74, pl. 41, fig. 3.

Balanus (Actinobalanus) bisulcatus Darwin. MORONI, 1967, p. 925.

Actinobalanus bisulcatus (Darwin). NEWMAN and ROSS, 1976, p. 49.

Actinobalanus bisulcatus plicatus (Darwin). NEWMAN and ROSS, 1976, p. 49.

non *Balanus bisulcatus* Darwin. ALESSANDRI, 1907, p. 286, pl. 9, fig. 30; 1922, p. 221; WITHERS, 1953, p. 58, 62; DAVADIE, 1963, p. 75 (in part).

Lectotype: Shell figured by Darwin (1854b, tab. 2, fig. 2a); British Museum (Natural History).

Type locality: Coralline Crag, Ramsholt, Gedrave, Sutton, England.

Emended diagnosis: Parietes smooth or markedly costate; radii narrow or broad, disparietal; scutum with two to four external longitudinal furrows; scutal adductor ridge prominent, length greater than one-half length of occludent margin; scutal articular ridge not extending beyond tergal margin; tergum broad, with convex scutal margin; tergal spur very short, less than one-tenth length of plate, broad, occupying one-half width of basal margin, subtruncate basally, nearly confluent with basiscutal angle; juncture of spur and carinal side of basal margin arcuate.

Geologic and geographic distribution: Pliocene, western Europe: Coralline Crag, Sutton, England; Rauville, Cotentin, France; Bolderberg, near Hasselt, Belgium; Karrendijke Formation, Vrasenedok, Kallo, Antwerp, Belgium (new locality, collected by J. S. H. Collins, 1985).

Disposition of specimens: Hypotypes USNM 423878 through 423881, and paratype lot USNM 423882 from the Pliocene Karrendijke Formation, Belgium are deposited in the collection of the Department of Paleobiology, National Museum of Natural History, Washington, D. C. Reference specimens are deposited in the British Museum (Natural History), London.

Discussion: This species is distinguished from others in the genus *Actinobalanus* by the radial ornament and long, prominent adductor ridge of the scutum, and the broad, short, basally subtruncate tergal spur. There does not appear to be any justification for maintaining a taxonomic distinction between individuals with smooth and costate shells, even in the absence of

opercular plates of the latter. As indicated by Darwin (1854b, p. 27-28), the only other observed differences are the narrower and more steeply sloping radii, and the crenate rather than smooth sutural edges of the alae of costate forms. As both costate and smooth shells are found in all other species of *Actinobalanus,* and as the costate shells occur with the non-costate or partially costate shells of typical *A. bisulcatus,* we are placing *A. bisulcatus plicatus* in synonymy with *A. bisulcatus.* There is the possibility that the unusually costate juvenile shell figured by Darwin (1854b, tab. 2, fig. 2d) represents a different species and, perhaps, genus. Darwin's illustration suggests that the radii of this specimen are transparietal and that the orifice is considerably smaller and untoothed. In the absence of opercular plates and a detailed description of the shell, however, no definite conclusions can be drawn on the affinities of this specimen. *Actinobalanus bisulcatus* (including the variety *plicatus* Darwin) was reported by Alessandri (1907, 1922) and Davadie (1963) from the Eocene (Marinesian), Oligocene and Miocene of France, and from the Miocene of England, Belgium and Germany. To our knowledge, all of these extralimital records are based on shells or parts of shells without opercular plates, and should not be considered further until corroborated. It is particularly unlikely that any of the Paleogene specimens ascribed to *A. bisulcatus* can be attributed to *Actinobalanus.*

ACTINOBALANUS DOLOSUS (Darwin, 1854)

Balanus dolosus DARWIN, 1854a, p. 295, pl. 8, fig. 7; 1854b, p. 28, tab. 2, figs. 3a-3d.

Balanus (Armatobalanus) dolosus Darwin. DAVADIE, 1963, p. 76, pl. 41, figs. 4, 4a, 5; pl. 42, fig. 3; pl. 46, figs. la-b, 2a-b.

Balanus (Actinobalanus) dolosus (Darwin). MORONI, 1967, p. 925.

Actinobalanus dolosus (Darwin). NEWMAN and ROSS, 1976, p. 49.

non *Balanus dolosus* Darwin. LECOINTRE, 1910, p. 2, pl. 10, figs. 1-6 [Miocene, Faluns de Touraine, France].

non *Balanus (Armatobalanus) dolosus* Darwin. DAVADIE, 1963, p. 77 [records from Miocene of France, Pliocene of Norway].

Lectotype: Scutum and tergum illustrated by Darwin (1854b, tab. 2, figs. 3c-d).

Type locality: Unknown.

Emended diagnosis: Parietes smooth or costate; radii narrow to broad, paraparietal; scutum without external radial ornament; scutal adductor ridge prominent, length greater than one-half length of occludent margin; scutal articular ridge not extending beyond tergal margin; tergum broad, with convex scutal margin; tergal spur long, over one-fifth length of plate, occupying about one-third width of basal margin, basally rounded, slightly removed from basiscutal angle; sides of spur parallel; juncture of tergal spur and carinal side of basal margin angulate.

Geologic and geographic distribution: Lower-Middle Pleistocene, England: Red Crag, Sutton; Mammaliferous Crag; Norwich Crag, Postwick, near Norwich.

Discussion: This species most closely resembles *A. bisulcatus,* differing in lacking external radial ornament on the scutum, and in having a much longer and narrower tergal spur and paraparietal rather than disparietal radii. *Actinobalanus dolosus* was reported from the Miocene of France and the Pliocene of Norway by Davadie (1963), but as neither of these records are supported by description or illustration and are considerably older than Darwin's English records, we do not consider them valid at this time. The three shells without opercular plates illustrated by Lecointre (1910) from the Miocene of France are similarly unidentifiable.

PLATE 1

Figures

1-4. *Actinobalanus bisulcatus,* Karrendijke Formation, Antwerp, Belgium. 1, USNM 423878 (hypotype), interior of scutum, 31X; 2, USNM 423879 (hypotype), interior of tergum, 28X; 3, USNM 423880 (hypotype), exterior of tergum, 31X; 4, USNM 423881 (hypotype), exterior of scutum, 27X.

5-7. *Actinobalanus collinsi* n. sp., Berchem Formation, Edegem sands, Antwerp, Belgium. 5, USNM 423884 (paratype), exterior of tergum, 28X; 6, USNM 423885 (paratype), interior of scutum, 26X; 7, USNM 423886 (paratype), exterior of scutum, 22X.

PLATE 1

ACTINOBALANUS COLLINSI new species
Plate 1, figs. 5-7; Plate 2; Plate 3, figs. 1-4

Diagnosis: Parietes usually coarsely costate; radii narrow, disparietal; scutum thick, without external radial ornament; scutal adductor ridge short, prominent, centrally located; scutal articular ridge extends well beyond tergal margin; tergum thick, narrow, with straight scutal margin produced into broad shelf; tergal spur short, acuminate, occupying less than one-third width of basal margin; juncture of tergal spur with carinal side of basal margin arcuate.

Description: Shell known only from disarticulated compartmental plates, moderately small, the larger rostra about one cm in height; parietes thick, solid, coarsely plicate; radii solid, narrow, with steeply-sloping summits and smooth sutural margins; alae broad, thin, with convex, welted summits separated from rest of ala by deep groove and marked by sharply upturned growth lines; sutural edges of alae thin, smooth; sheath occupying upper half to two-thirds of interior of compartmental plate; basal margin of sheath removed from interior of plate, leaving broad, shallow space under sheath; interior of parietes with numerous, prominent, flat-topped to acute longitudinal ribs that extend from basal margin to base of sheath; basal edges of internal ribs acuminate, not denticulate; interior of compartments framed on either side by thickened borders of radii and alae; calcareous basis thickening toward margin, tubiferous.

Scutum thick, markedly bowed outwardly between basal margin and apex, broad, with basal margin as long or longer than tergal margin; exterior ornamented solely by prominent, closely-spaced, cord-like growth ridges; occludent margin thickened to form broad, beveled shelf in upper two-thirds of plate; lower third of occludent margin usually denticulate; articular ridge thick, prominent, occupying upper two-thirds of tergal margin partially reflexed over deep, narrow articular furrow, and extending well beyond tergal margin; adductor ridge short, straight, prominent, acute, parallel to occludent margin, centrally located on plate, and partially overhanging shallow, elongate pit below ridge; adductor muscle pit elongate, parallel to adductor ridge, moderately deep; lateral depressor muscle pit small, very deep, round to elliptical, situated at basitergal angle on basal margin; apical part of scutum markedly rugose.

Tergum thick, flat, usually narrow; exterior marked by prominent, closely-spaced growth ridges crossed by radial striae on carinal side; scutal margin straight; carinal margin convex without well-developed zone of upturned growth lines; articular ridge prominent, triangular, highest in apical third of plate and extending to basal margin, partially reflexed over broad, deep articular furrow; depressor muscle crests short, prominent, seven in number, located on protuberant corner of basal margin; interior of plate markedly rugose; spur fasciole flat or slightly depressed, bordered on scutal side by narrow groove; tergal spur short, occupying less than one-fourth of basal margin, acuminate, removed by a distance nearly equal to its own length from basiscutal angle; juncture of spur with carinal side of basal margin deeply arcuate to subangular.

Holotype: Tergum, USNM 423883.

Type locality: Berchem Formation, Edegem sands, Metro works spoil heaps, Borgerhout, Antwerp, Belgium; J. S. H. Collins, collector, 1985.

Material: Over 100 disarticulated compartmental plates, 23 scuta and 7 terga from the type locality.

Disposition of types: Holotype USNM 423883, paratypes USNM 423884 through 423896, and paratype lot USNM 423897 are in the collection of the Department of Paleobiology, National Museum of Natural History, Washington, D. C; reference specimens are in the collection of the British Museum (Natural History), London.

Geologic and geographic distribution: Lower Miocene, Belgium. Known only from the type locality.

Etymology: This species is named for J. S. H. Collins, collector and donator of the only known specimens, in recognition of his numerous contributions to our understanding of fossil Cirripedia.

Discussion: Actinobalanus collinsi is most readily distinguished from other species of *Actinobalanus* by its coarsely plicate shell, unusually thick opercular plates and the broadly reflexed shelf developed

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PLATE 2

Figures

1-7. *Actinobalanus collinsi* n. sp., Berchem Formation, Edegem sands, Antwerp, Belgium. 1, USNM 423887 (paratype), exterior of scutum, 20X; 2, USNM 423888 (paratype), exterior of tergum, 34X; 3, USNM 423889 (paratype), interior of tergum, 28X; 4, USNM 423883 (holotype), interior of tergum, 34X; 5, USNM 423890 (paratype), interior of tergum, 31X; 6, USNM 423891 (paratype), interior of scutum, 24X; 7, USNM 423892 (paratype), interior of scutum, 19X.

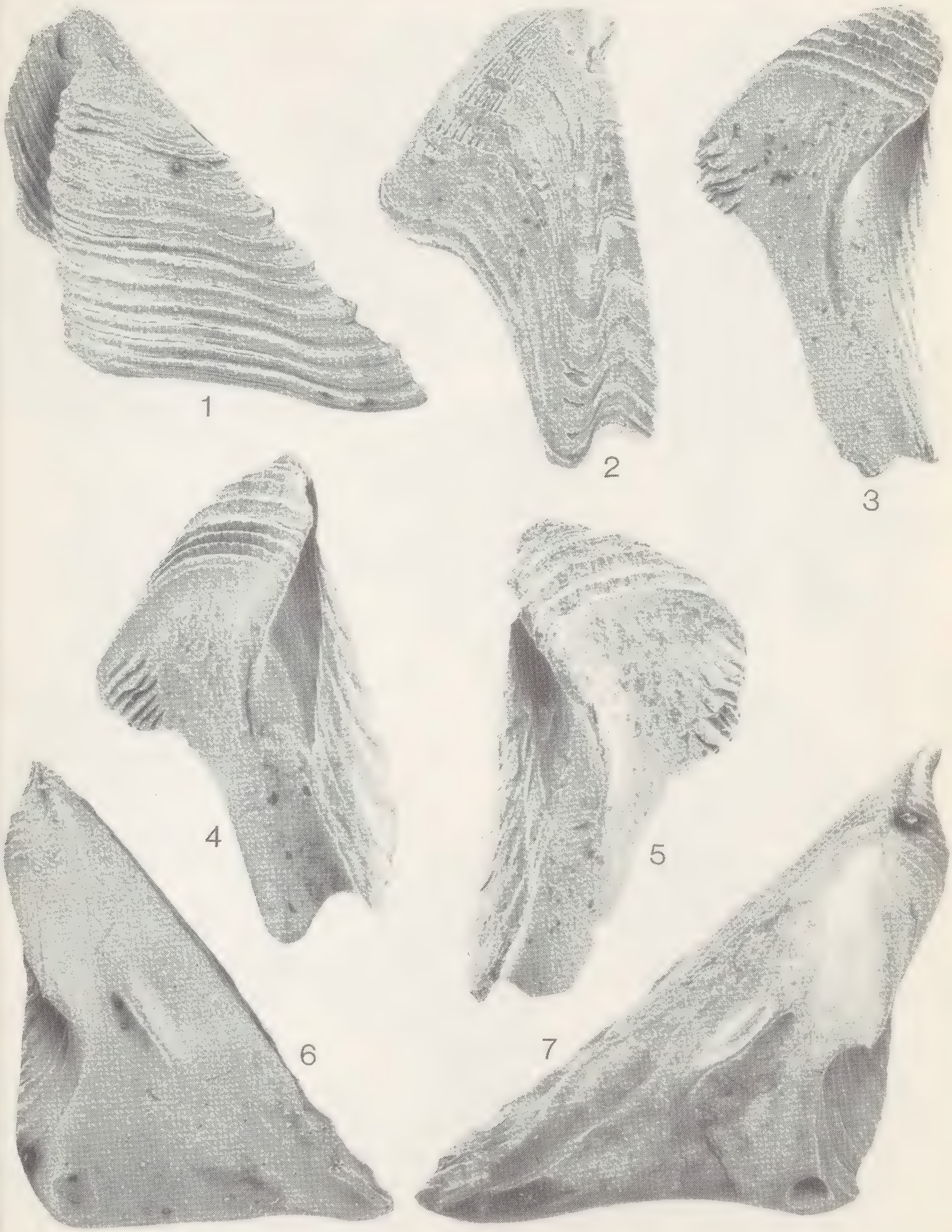


PLATE 2

on the scutal margin of the tergum. The Miocene reports of *Actinobalanus bisulcatus* by Alessandri (1907, 1922), Withers (1953, p. 58) and Davadie (1963), and of *A. dolosus* by Davadie (1963) from Belgium and France may represent *A. collinsi*.

ACTINOBALANUS FLORIDANUS new species
Plate 3, figs. 5-9; Plate 4

Diagnosis: Parietes smooth or rarely plicate; radii narrow, disparietal; Scutum without external radial ornament; basal margin about two-thirds length of occludent margin; scutal adductor ridge prominent, short, about one-quarter length of occludent margin; scutal articular ridge extending beyond tergal margin; tergum broad, with straight scutal margin; carinal margin with upturned growth ridges; tergal spur short, occupying about one-third of basal margin; basally rounded; juncture between spur and carinal side of basal margin deeply arcuate.

Description: Shell small, up to 5 mm in carinorostral diameter, conic, with moderately-toothed orifice; parietes thin, solid, smooth, rarely plicate; radii solid, moderately narrow, with steeply-sloping summits and thin, non-septate sutural margins; alae broad, thin, with convex, welted summits and thin, non-septate sutural margins; sheath occupying upper half to upper two-thirds of compartmental plate; basal margin of sheath either confluent with, or only slightly removed from plate interior; interior of parietes with numerous, prominent, flat-topped longitudinal ribs that fade toward, but extend to base of sheath; basal edges of internal longitudinal ribs thin, not denticulate; interior of compartments framed on either side by thickened borders of alae and radii; calcareous basis thin near center, thickening toward margin, tubiferous; basal tubes dividing near margin in some specimens.

Scutum thin, outwardly bowed between basal margin and apex; relatively narrow, with basal margin about two-thirds length of occludent margin; exterior ornamented solely by widely spaced, sometimes prominent growth ridges; occludent margin often thickened into flat, broad shelf in apical half, with prominent denticles lining basal half; articular ridge prominent, thickened, occupying upper half to two-thirds of tergal margin, reflexed over broad, deep articular furrow, and extending well beyond tergal margin; adductor ridge short, about one-fourth length of occludent margin, straight, prominent, acute, parallel to occludent margin, centrally located on plate; adductor muscle pit elongate, parallel to adductor ridge, deep; an elongate pit also borders the adductor ridge on its tergal side; lateral depressor muscle pit small, round, moderately deep, on basal margin slightly removed from basitergal angle; apical part of interior of scutum rugose.

Tergum thin, broad, triangular, flat; exterior marked by indistinct or occasionally prominent, widely-spaced, growth ridges; scutal margin straight; carinal margin convex, marked externally by narrow band of upturned growth ridges; articular ridge prominent, triangular, best developed in apical third of plate and fading toward, but extending to basal margin, partially reflexed over broad, deep articular furrow; depressor muscle crests short, prominent, closely-spaced, six in number; interior of plate markedly rugose; spur fasciole flat to slightly depressed, usually bordered by impressed line on scutal side; tergal spur short, basally rounded, occupying about one-fourth of basal margin, removed by a distance slightly less than its length from the basiscutal angle; juncture of spur with carinal side of basal margin deeply arcuate.

Holotype: Shell with opercular plates, USNM 423898.

Type locality: Limy facies of the basal Chipola Formation, Alum Bluff Group, at power line on north bank of Ten Mile Creek, 1.3 mi north-northwest of the mouth of the creek at Bailey's Ferry on the Chipola River, Calhoun County, northwestern Florida (= TU 830); Earl Manning, collector, March 27, 1986.

Material: Twenty complete shells, several with opercular plates in growth position; and over 100 compartmental plates.

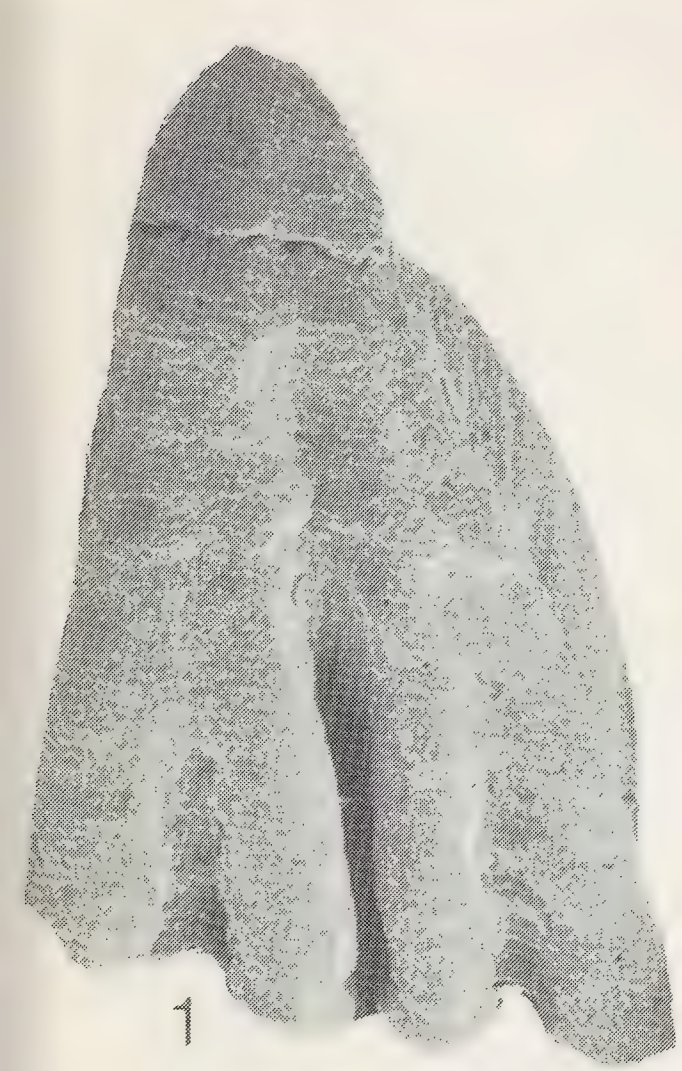
Disposition of types: Holotype USNM 423898, paratypes USNM 423899 through 423908, and paratype lot 423909 are in the collection of the Department of Paleobiology, National Museum of Natural History, Washington, D. C.

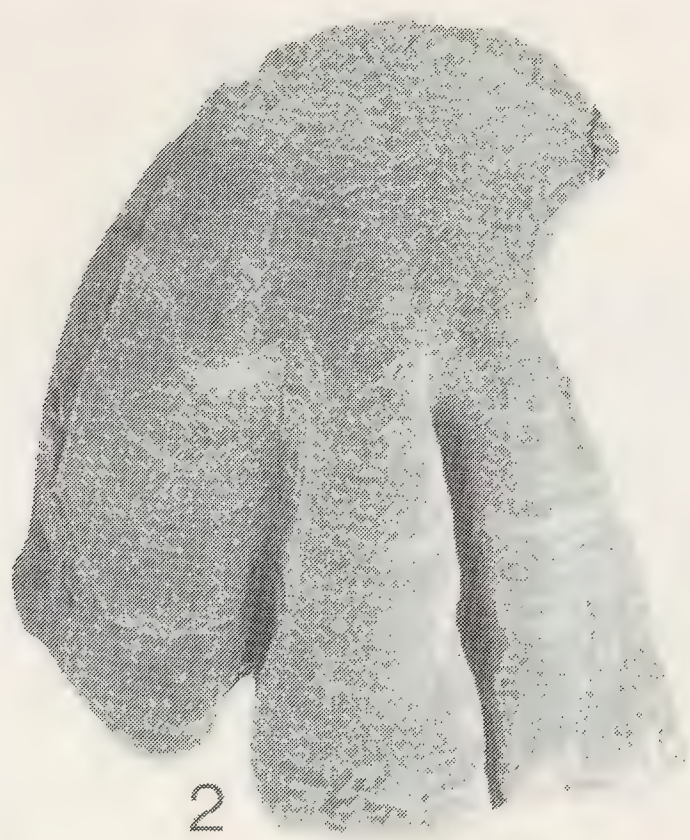
PLATE 3

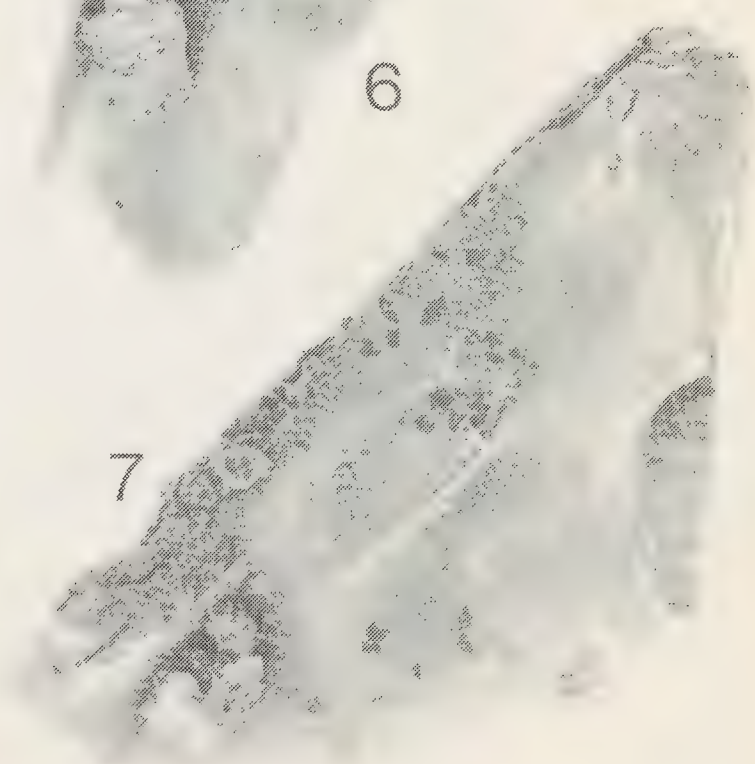
Figures

1-4. *Actinobalanus collinsi* n. sp., Berchem Formation, Edegem sands, Antwerp, Belgium, all 12X. 1, USNM 423893 (paratype), exterior of lateral plate; 2, USNM 423894 (paratype), exterior of lateral plate; 3, USNM 423895 (paratype), interior of rostral plate; 4, USNM 423896 (paratype), exterior of lateral plate.

5-9. *Actinobalanus floridanus* n. sp., Chipola Formation, Calhoun County, Florida, all 33X. 5, USNM 423899 (paratype), exterior of scutum; 6, USNM 423898 (holotype), interior of tergum; 7, USNM 423898 (holotype), interior of scutum; 8, USNM 423900 (paratype), exterior of scutum; 9, USNM 423901 (paratype), interior of tergum.







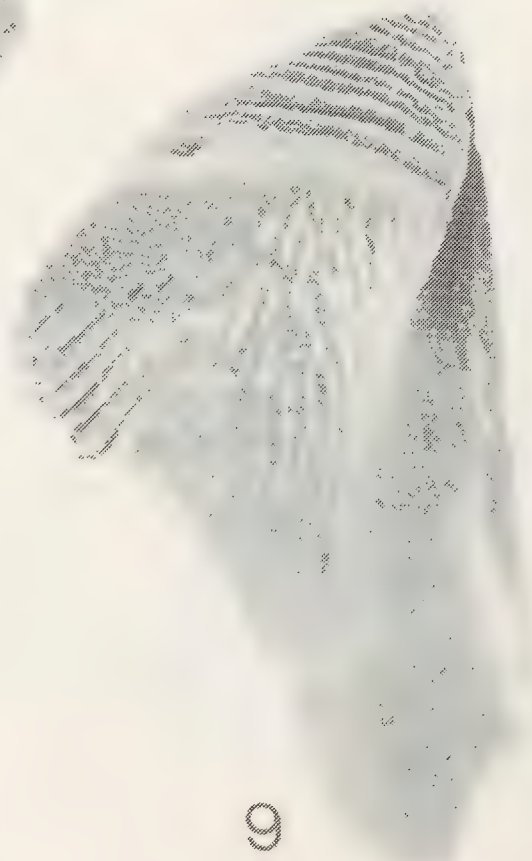


PLATE 3

Geologic and geographic distribution: Lower Miocene (Burdigalian), Florida. Known only from the type locality.

Etymology: This species is named for the State of Florida.

Discussion: Actinobalanus floridanus is the only species of the genus known to occur outside of the western European region, and is approximately the same age as the oldest known European species, *A. collinsi* from the Miocene of Belgium. *Actinobalanus floridanus* closely resembles the type species, *A. actinomorphus,* especially in the morphology of the opercular plates. However, the scutum of the new species is narrower and has a longer, more prominent adductor ridge, the external growth ridges of the tergum are upturned along the carinal margin, and the juncture between the tergal spur and the carinal side of the basal margin is deeply, rather than gently arcuate, imparting greater definition to the tergal spur. In addition the shell of *A. floridanus* is typically smooth, with only the rare example being plicate, whereas that of *A. actinomorphus* is usually markedly costate, although examples with smooth shells are known. Most individuals have a relatively flat basis such as a group found on a naticid shell, but others replicate the ornament of the ribbed molluscs to which they were attached. A smaller number are elongate in the carinorostral direction, with their lateral margins curled under to form a clasping basis, indicating attachment to cylindrical objects, possibly echinoid spines.

IV. KEY TO THE SPECIES OF *ACTINOBALANUS*

1. Exterior of scutum with 2-3 distinct radial furrows . . . . . *Actinobalanus bisulcatus*
1. Exterior of scutum with growth ridges only 2
2. Scutal margin of tergum convex, tergal spur broad, about one-third width of basal margin with nearly parallel sides; length of scutal adductor ridge over one-half length of occludent margin . . . . . *Actinobalanus dolosus*
2. Scutal margin of tergum straight, tergal spur narrow, no more than one-third width of basal margin, with diverging sides; length of scutal adductor ridge no more than one-quarter length of occludent margin 3
3. Opercular plates thick; scutal margin of tergum produced into broad shelf; shell coarsely plicate . . . . . *Actinobalanus collinsi*
3. Opercular plates thin; scutal margin of tergum not developed into broad shelf; shell smooth or costate 4
4. Shell usually costate; length of scutal adductor ridge less than one-fifth length of occludent margin; basal margin of scutum nearly three-fourths length of occludent margin; tergum without upturned growth ridges along carinal margin . . . . . *Actinobalanus actinomorphus*
4. Shell usually smooth; length of scutal adductor ridge one-quarter length of occludent margin; basal margin of scutum less than two-thirds length of occludent margin; tergum with upturned growth ridges along carinal margin . . . . *Actinobalanus floridanus*

V. ACKNOWLEDGMENTS

We thank J. S. H. Collins, London, England for the specimens of *A. bisulcatus* and *A. collinsi,* and Earl Manning, Louisiana

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PLATE 4

Figures

1-8. *Actinobalanus floridanus* n. sp., Chipola Formation, Calhoun County, Florida. 1, USNM 423902 (paratype), interior of lateral plate, 13X; 2, USNM 423898 (holotype), oblique view of shell, 12X; 3, USNM 423903 (paratype), interior of rostral plate with attached tubiferous basis, 34X; 4, USNM 423904 (paratype), exterior of articulated rostral and lateral plates, 12X; 5, USNM 423905 (paratype), interior of carinolateral plate, 13X; 6, USNM 423906 (paratype), interior of articulated carinolateral and lateral plates with attached tubiferous basis, 20X; 7, USNM 423907 (paratype), exterior of partial articulated cylindric shell, 14X; 8, USNM 423908 (paratype), interior of carinolateral and lateral plates with attached tubiferous basis, 33X.

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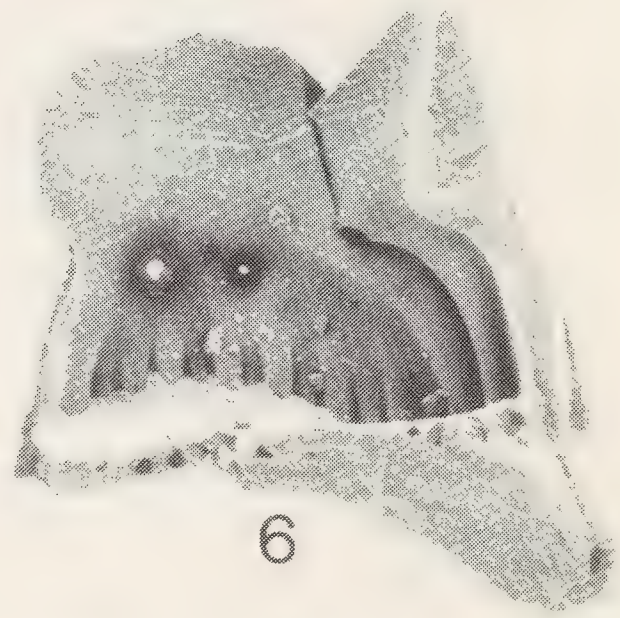

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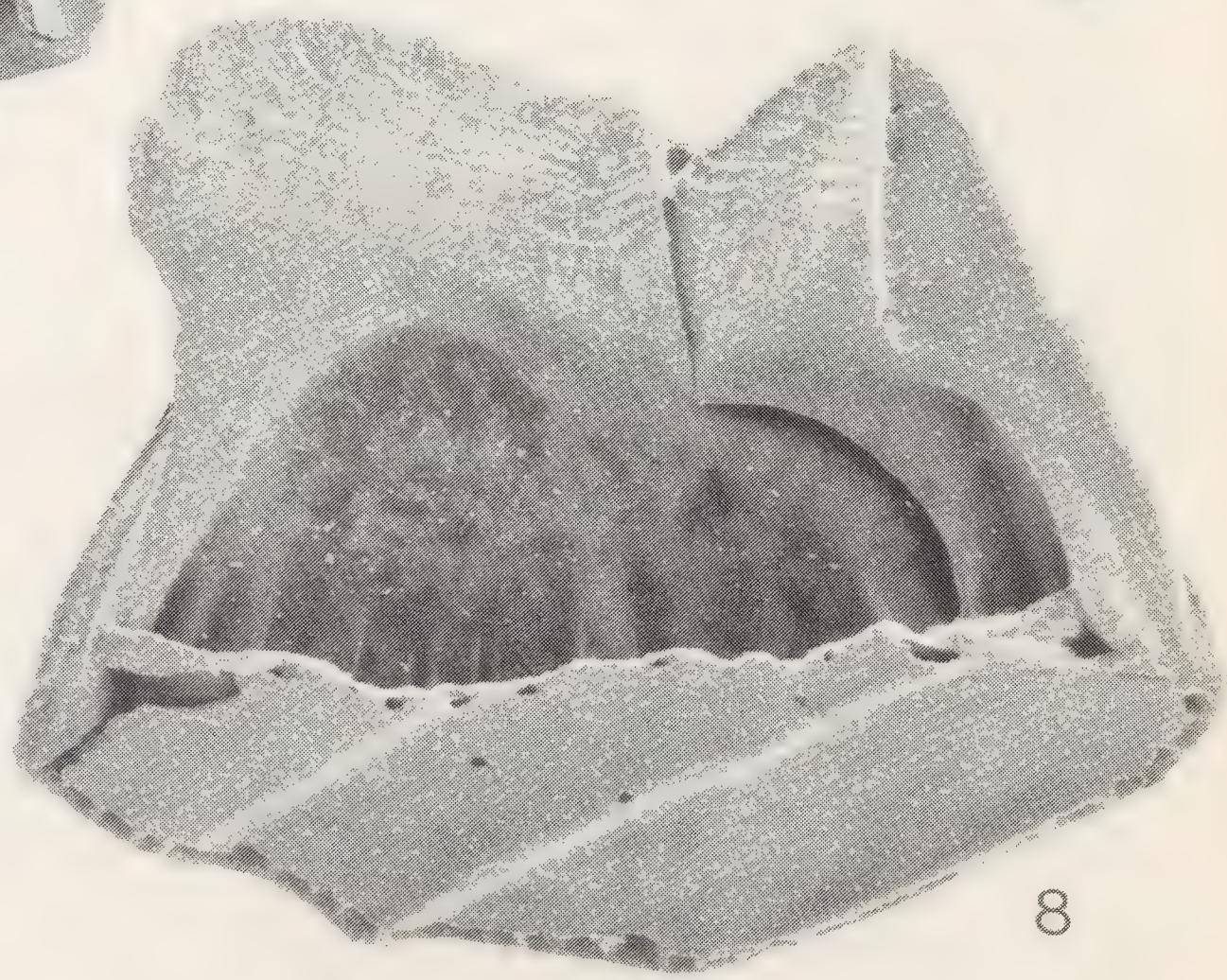

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PLATE 4

State University for the specimens of *A. floridanus* described herein. Acknowledgment is made to the donors of The Petroleum Research Fund, administered by the American Chemical Society, for support of this research.

VI. LITERATURE CITED

ALESSANDRI, G. DE, 1906, Studi monografici sui Cirripedi fossili d'Italia: Palaeontogr. Italica, Mem. di Paleont., v. 12, p. 207-324.

ALESSANDRI, G. DE, 1907, Osservazioni sopra alcuni Cirripedia fossili della Francia: Atti Soc. Italiana Sci. Nat., v. 45, p. 251-291.

ALESSANDRI, G. DE, 1922, Cirrhipedes du Miocene de l'Aquitaine: Actes Soc. Linn. Bordeaux, v. 74, p. 203-227.

BUCKERIDGE, J. S., 1983, Fossil barnacles (Cirripedia: Thoracica) of New Zealand and Australia: New Zealand Geol. Survey Bull. 50, 151 p.

DARWIN, C., 1854a, A monograph on the subclass Cirripedia, Balanidae and Verrucidae: Ray Society, London, v + 684 p.

DARWIN, C., 1854b, A monograph on the fossil Balanidae and Verrucidae of Great Britain: Palaeontographical Society, London, 44 p.

DAVADIE, C. 1963, Etude des Balanes d'Europe et d'Afrique. Systimatique et structure des Balanes fossiles d'Europe et d'Afrique: Iditions Centre National de la Recherche Scientifique, Paris, 146 p.

LECOINTRE, P., 1910, Les formes diverses de la vie dans les Faluns de la Touraine. Cirrhiphdes fossiles des Faluns: La Feuille des Jeunes Natural., ser. 4, no. 477, p. 137-140.

MORONI, M. A., 1967, Classificazione sottogenerica ed affinità di *Balanus actinomorphus* Moroni, 1952: Riv. Italiana Paleontol., v. 73, no. 3, p. 919-928.

MORONI RUGGIERI, M. A., 1952, Richerche sui Cirripedi fossili italiani: Giorn. di Geol., ser. 2, vol. 22, p. 66-81.

NEWMAN, W. A., and A. ROSS, 1976, Revision of the balanomorph barnacles; including a catalog of the species: San Diego Soc. Nat. Hist., Mem. 9, 109 p.

NEWMAN, W. A., V. A. ZULLO, and T. H. WITHERS, 1969, Cirripedia, p. R206-R295. *In* R. C. Moore (ed.), Treatse on Invertebrate Paleontology, Part R, Arthropoda 4(1): Geol. Soc. Amer. and Univ. Kansas Press, Lawrence, Kansas.

WITHERS, T. H., 1953, Catalogue of fossil Cirripedia in the Department of Geology, Volume III, Tertiary: Brit. Mus. (Nat. Hist.), London, xv + 396 p.

AN OVERVIEW OF THE CHIPOLA FORMATION, NORTHWESTERN FLORIDA

EMILY H. VOKES
TULANE UNIVERSITY

The Alum Bluff Group of northwestern Florida includes four "formations" – the Chipola, Oak Grove, Shoal River, and Hawthorn units (Fig.1). Of these, the Chipola and Oak Grove are believed, on the basis of molluscan fauna, to be stratigraphic equivalents, and are of late Early Miocene age (Akers, 1972). The Shoal River and Hawthorn are assumed to be Middle Miocene.

The name, Chipola Marl, was first suggested in field notes by collector Frank Burns, of the U. S. Geological Survey, and was originally used as a member of the Alum Bluff Formation; however, Julia Gardner (1926, p. 1) considered the faunas of the different units to be so completely distinct that she elevated the members to the rank of formation. This is not very good stratigraphic technique, as a formation is a lithologic unit, but there is a lithologic difference. The Chipola is a blue-gray to yellowish brown (depending on how deeply weathered it is), highly fossiliferous marl. The Oak Grove and Shoal River units are sands, presumably very near-shore.

The Hawthorn, as Puri and Vernon (1964, p. 145) noted, "is the most misunderstood formational unit in the southeastern United States. It has been a dumping ground for alluvial, terrestrial, marine, deltaic, and pro-deltaic beds of diverse lithologic units." According to these authors, the Hawthorn, which includes phosphatic, dolomitic, algal, and quartzose beds, "indicates the presence of a massive delta along the Georgia, Alabama, and Florida lines" (1964, p. 153). The Hawthorn outcrops only to the east of the Apalachicola River but Gardner included a number of Hawthorn localities in what she called "Chipola Formation."

The typical Chipola Formation, that is, the formation as it is developed in the type area (Fig. 2), occupies a relatively small area, comprising the outcrops on the Chipola River, west of Blountstown, together with its tributaries, and at Alum Bluff, on the Apalachicola River just to the northeast of Blountstown.

In the late nineteen fifties there was no precise information on localities. The USGS localities collected by Burns were said to be "Chipola River, one mile below Bailey's Ferry" and "Tenmile Creek, one mile west of Bailey's Ferry." Cooke's *Geology of Florida* (1945, p. 163) noted that "the type locality [of the Chipola Formation] is on the west bank of the Chipola on the John M. P. McCleland *[sic]* Farm, in the SW 1/4 SW 1/4 sec. 8, T.1N., R.9W., 2 1/4 miles east of Carr." He added that Burns' locality on Tenmile Creek "is probably at or near the crossing of the present State Highway 84 [now State 73] (from Marianna to Clarksville)."

The locality at the bridge (TU 70) is about two miles west of the river and the fauna in no way resembles that said to occur at USGS 2212, one mile west of Bailey's ferry. Thus, from 1958 to 1961 we searched for Bailey's Ferry, thinking this would be the key to the localities. We were not in the least helped by the statement in Dall and Stanley-Brown (1894, p. 159), who said: "The principal localities of interest on the Chipola River are those near a point called Bailey's Ferry, where a bridge has replaced the former ferry ... Just above the bridge, on the right bank, the ferrugineous Chipola marl may be seen rising two or three feet above the water edge ... This is said by residents to be the most northerly point on the Chipola river where the yellow marl is visible in the bank ... A half mile below the bridge is a farm belonging to Mr. John McClellan *[sic]*, on which a fairly good section can be studied."

However, the bridge is about four miles below where Bailey's ferry (Fig. 3) is located (once we finally found it), McClelland's farm (Fig. 4) is a scant half-mile below the ferry but far above the bridge. Once we found Bailey's Ferry, we could locate the section at McClelland's farm, which does rest on the Chattahoochee Limestone (Figs. 5, 6), as Burns had noted, so there is no doubt that this is the correct locality. It is not in section 8, but about 3/4 mile below it. Nor is it one mile below Bailey's Ferry, it is less than one-half mile.

Subsequent work over the years has resulted in some 60 localities (Fig. 7) on the Chipola River and its tributaries – Tenmile

Creek to the west, and Farley Creek to the east. In all, there is a total outcrop of about 4 miles exposed along the river, 1 3/4 miles on Farley, and 1 1/2 miles on Tenmile, or approximately 7 linear miles of exposure.

Here we have discovered one of the most ecologically diverse faunas anywhere in the western Atlantic. The position of the river, which cuts almost directly across the strike of the formation, together with its two tributaries, one east and one west, gives a beautiful three dimensional picture of the area.

The Chipola is a moderately small river (Fig. 8), rising in southern Alabama, just south of Dothan. It flows due south for

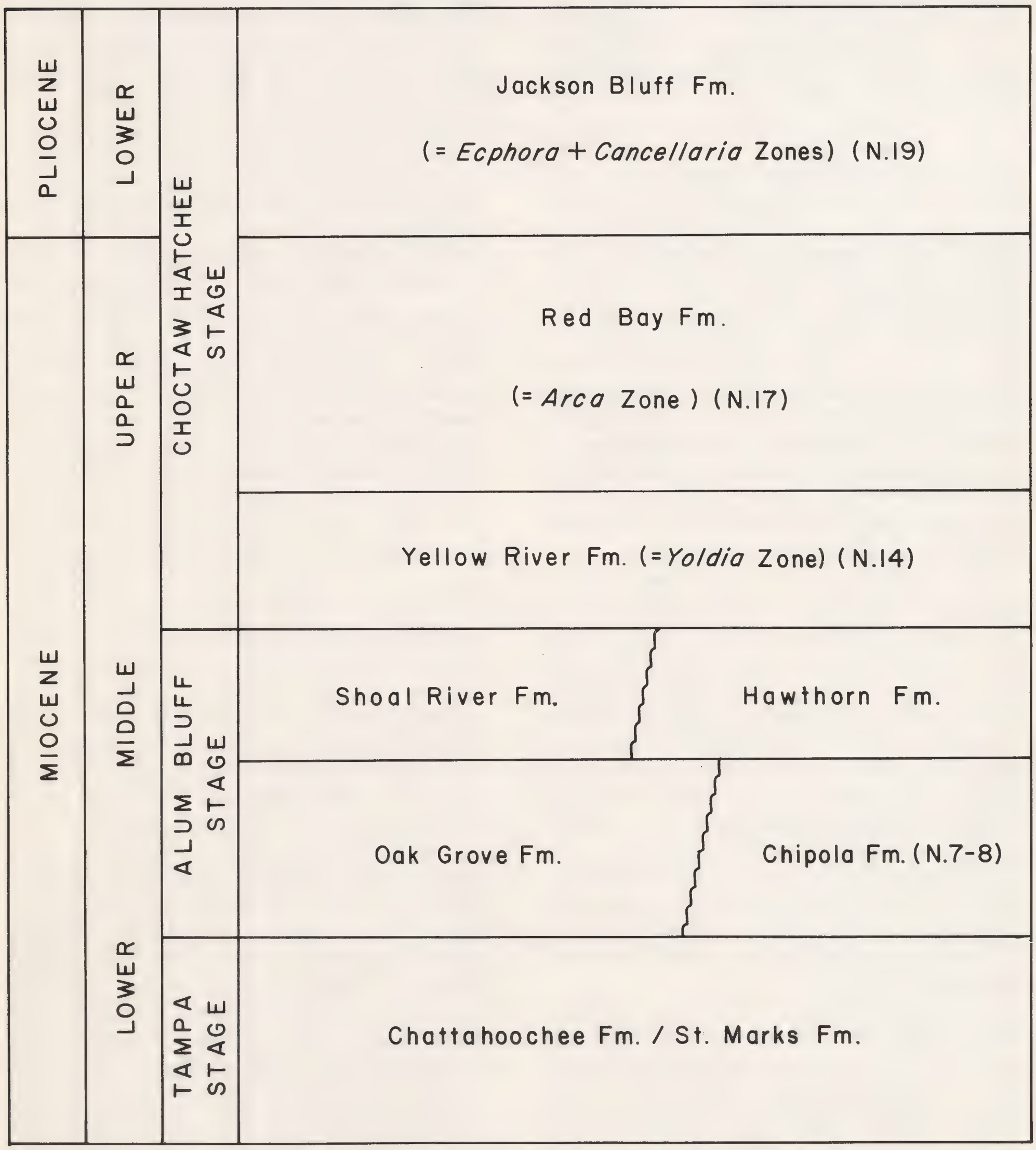

Figure 1. Correlation chart of the Miocene and Pliocene formations of northwestern Florida. Only those units with N. numbers have been accurately dated (Akers, 1972), the others are only approximately correct.

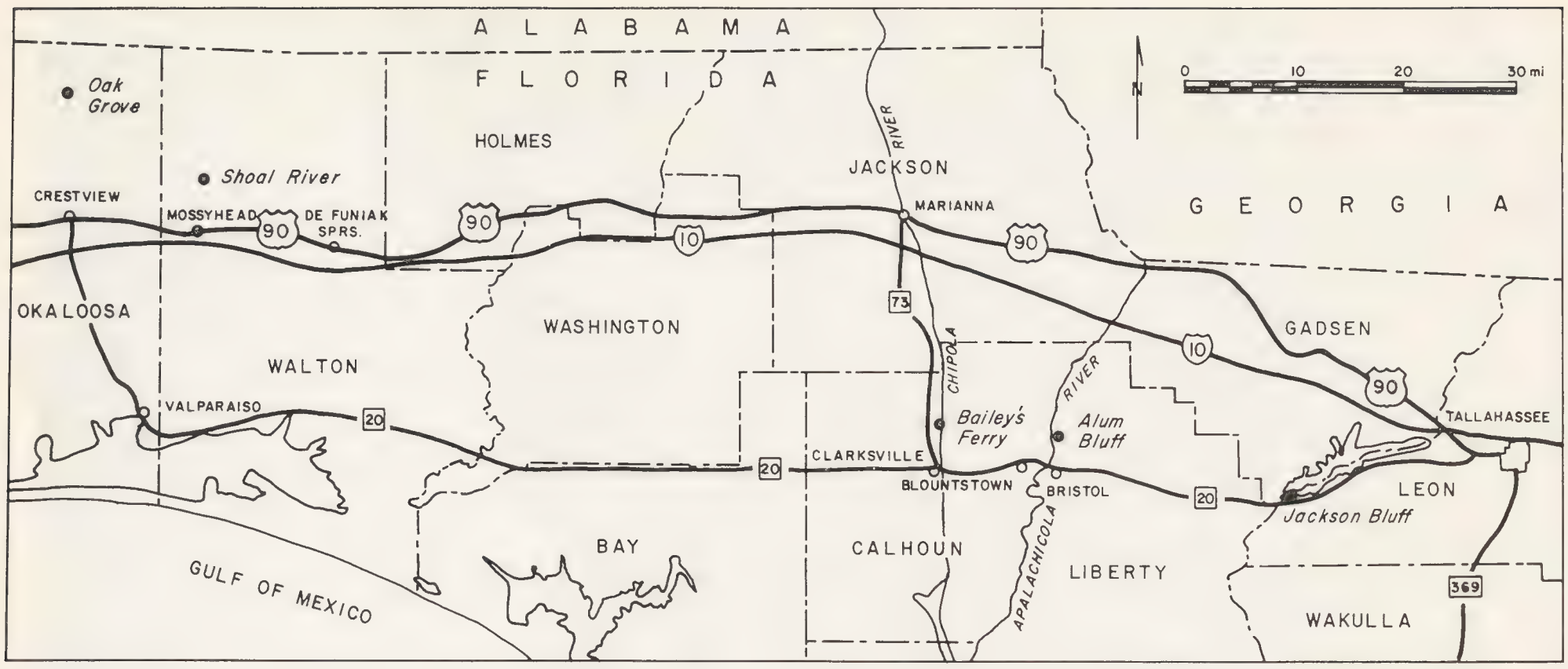

Figure 2. Location of relevant localities in northwestern Florida, showing the disjunct nature of the outcrops of the members of the Alum Bluff Group. The Hawthorn Formation is only to the east of the Apalachicola River, principally north of Gainesville in peninsular Florida.

about one hundred miles to Dead Lake, where it joins the Apalachicola River. For much of the distance between Marianna and Bailey's Ferry, it flows in a canyon cut into the Marianna and Chattahoochee limestones. Bailey's Ferry is located where the Chattahoochee Limestone is just at water-level, making it possible to drive a wagon down to the river without sinking up to the axles in Chipola mud. As one moves downstream, the first outcrop of Chipola Marl is at the aforementioned McClelland's farm, and because of the almost flat-lying beds, here the limestone is also just at water level. These basal beds contain many specimens of *Orthaulax*, *Strombus*, oysters, Amusiums, Nodipectens, and solitary corals, evidently a result of the hard bottom, for we also see this same fauna on Tenmile Creek at the basal contact.

For the next four miles downstream there is a series of low exposures, usually no more than a couple of feet high, that include a shore-line beach (TU 459), complete with specimens of *Donax* and some fresh-water elements, an oyster reef (TU 550), a coral patch-reef (TU 547, 555), with a number of reef-dwelling mollusks not found anywhere else (such as *Pterynotus hoerlei* Vokes, 1972), then into a fine silty-clay (TU 549), reminiscent of the upper beds on Tenmile Creek.

Tenmile Creek (Fig. 9) is the major tributary of the Chipola River. It comes in from the northwest and enters the river at Bailey's Ferry. Where it is crossed by the Clarksville Highway it is deeply entrenched in a narrow canyon cut into the Chipola Formation, in beds that have a higher percentage of silt and less lime than in the more easterly outcrops. The beds are considered to be shallower in origin than those on the river, but in very quiet water, perhaps lagoonal.

As one moves downstream on Tenmile, the creek gets wider and the fossil fauna changes to become similar to that on the upper reaches of the river. The beds are more calcareous, and the paleo-depth is thought to be on the order of 10-15 fathoms (20 to 30 meters). This is the area that includes the "one mile west of Bailey's Ferry" locality of Burns. This facies extends for about one-half mile and then one comes to the base of the formation, where the Chipola can be seen to be resting on the Chattahoochee Limestone. For the last mile of its length, Tenmile flows in another canyon cut into the limestone, and at one time there is said to have been a natural bridge but it is now gone.

Farley Creek (Fig. 10) is a much smaller and shallower creek, only about four miles in length, flowing first to the south, then curving to the west, to enter the river

Figure 3. Bailey's Ferry, on the west side of the Chipola River, approximately 4 miles above the crossing of Florida Highway 20.

Figure 4. Graves of Mr. and Mrs. J. P. M. McClelland at Bailey's Cemetery, just west of Bailey's Ferry.

Figure 5. Outcrop of Chipola Formation resting on the harder Chattahoochee Limestone, at McClelland's Farm, west side of the Chipola River, about one-half mile below Bailey's ferry.

Figure 6. Collecting from the basal Chipola Formation at McClelland's Farm.

about a mile and one-half below McClelland's Farm. For much of its length it flows parallel to the strike of the formation, and the facies of the outcrop exposed for almost two miles along Farley tends to be much the same everywhere along its length. It is a bivalve-rich, miliolid limesand. There are many calcareous algae present, as well as numerous coral-heads, but no true reef is developed and we assume it is a shallow back-reef facies. In the upper reaches, one approaches the paleoshoreline, and then crosses into gravelly non-fossiliferous fluvial beds.

Thus, in this small area we have a section from shoreline to a patch-reef that was about two miles off-shore. To the west there were quiet muddy lagoons, to the

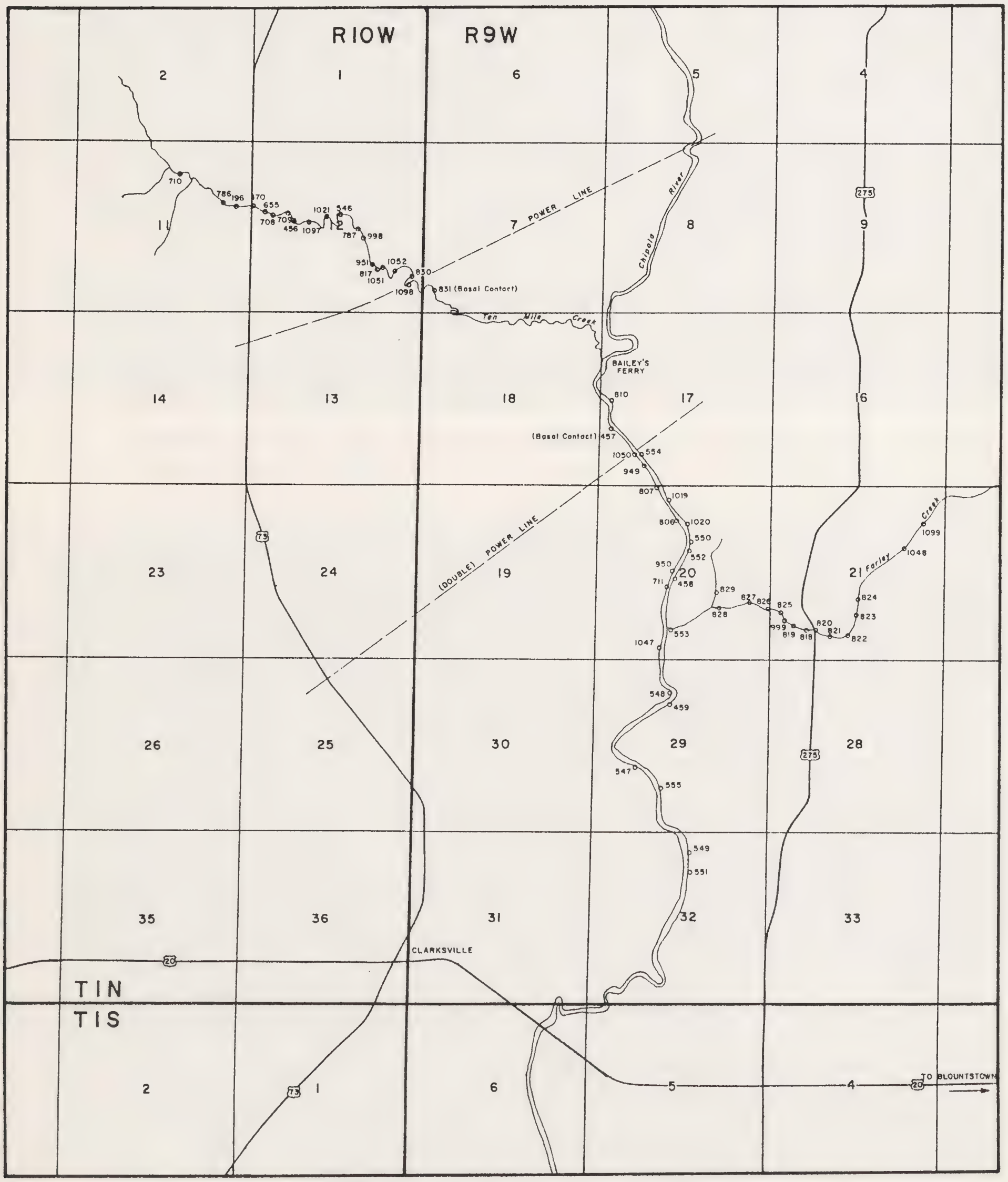

Figure 7. Tulane University fossil localities in the type area of the Chipola Formation, Calhoun County, Florida. Map based on U.S.G.S. topographic maps – Clarksville and Altha West quadrangles.

TABLE 1

FAMILY	Gardner had	total now
Ostreidae	5	6 (H.E. Vokes, 1977a)
Limidae	0	4 (H.E. Vokes, 1973)
Mytilidae	3	10 (H.E. Vokes, 1986)
Milthidae	3	4 (H.E. Vokes, 1969a; 1969b)
Cardiidae	13	16 (H.E. Vokes, 1977a; 1982)
Conidae	6	17 (Hoerle, 1976)
Olividae	3	6 (Drez, 1981)
Volutidae	2	4 (Hoerle & Vokes, 1978)
Turbinellidae	1	3 (E.H. Vokes, 1964)
Vasidae	1	4 (E.H. Vokes, 1966; 1970b)
Muricidae	11	37 (E.H. Vokes, 1963 *et. seq.;* Gertman, 1969; Vokes & D'Attillio, 1980; Vokes & Houart, 1986)
Calyptraeidae	4	9 (E.H. Vokes, 1975b)
Epitoniidae	1	3 (Olsson, 1967)
Cerithiidae	1	19 (Hoerle, 1972)
Potamididae	0	2 (Hoerle, 1972)
misc. unrep. families	0	15*
TOTAL	54	159

east more calcareous back-reef flats. Nowhere was the water probably more than 15 fathoms (30 meters) in depth – warm, clear, and absolutely teeming with life.

How many species of mollusk are there in the Chipola Formation? This a good question. Gardner, in the Introduction to her *opus magnum* on the Alum Bluff fauna (1926, p. 2), makes the statement that there are 439 species of Mollusca in the Chipola Formation.

However, if you count only her localities that are in the type area, that is the Chipola River, Tenmile Creek, and Alum Bluff, you get 421 species. Add to this 19 species described by Maury in 1910 and not included by Gardner, as she had no specimens, you arrive at 440 species.

So, I will base my calculations on this latter number. In those families that have been monographed more recently by either Harold Vokes, myself, or our associates (Fig. 11), we find that Gardner had a total number of 54 species in these selected families. To these have been added 105 more, for a total of 159 species in these families now.

Part of the reason for this great increase is because all of the material Gardner worked with was from two localities: "one mile west of Bailey's Ferry" (= TU 546), and "one mile below Bailey's Ferry," (= TU 457) both of which are in the basal beds and are extremely similar in facies. Her only other locality was the lower bed at Alum Bluff (= TU 453). This is also the reason why Maury (1910) was able to describe so many species from "Bailey's Ferry" that were not found in any of the USGS collections. Harris and Veatch, in making their collection for the Cornell Museum, obviously put a boat on the river and collected many of the sites that we subsequently located.

Table 1 gives an indication of the increases in some representative families. In all, from Gardner's count of 54 species in these selected families, we now have 159 species. This is very close to a 200% increase (162 = 200%). However, this is a bit misleading, as Gardner forgot (literally, according to Druid Wilson, pers. comm.) to do the Families Cerithiidae and Potamididae. If we include those species that Gardner should have had (that is, already de-

*See various *Notes on the fauna of the Chipola Formation,* Tulane Stud. Geol. Paleont., volume 10 *et seq.*

Figure 8. The Chipola River just below the crossing of Florida Highway 20, east of Clarksville, Calhoun County.

Figure 9. Tenmile Creek, near USGS locality 2213, "one mile west of Bailey's Ferry."

Figure 10. Farley Creek, on the east side of the Chipola River, approximately 3 miles north of Florida Highway 20.

Figure 11. The late Shirley E. Hoerle collecting on Tenmile Creek.

scribed by Dall or others), we see an addition of just one species of *Potamides*, and the Cerithiidae go from nine to 19, instead of from one to 19, as it appears in Gardner. If we go back and insert the missing species that she should have had in these two families, a more realistic value would be: Gardner's 63 species to 159 now, or a 150% increase.

Using this measure of increase, which is somewhat arbitrary I admit, and extrapolating it to the entire fauna we come up with an estimated total molluscan fauna in the type area of 1114 species. This is not an unreasonable figure for a tropical fauna. Woodring (1928, p. 22) estimated that a modern West Indian fauna, including every ecologic niche from shoreline to about 100 fathoms should include perhaps 1000 species. Nowhere does the Chipola approach such depths, but otherwise most of the ecologic niches are present.

When one compares this fauna to other described faunas in the region, one is more impressed by the great number. In the fossil record, the nearest approach to it is the Bowden, Jamaica, fauna monographed by Woodring (1925, 1928) with a total of 610 species. But the Bowden is unique in that this entire fauna comes from one locality – a roadcut, consisting of a shallow-water deposit, complete with boulders, wood, leaves, etc., moved by gravity downslope into very deep water, resulting in an almost complete cross-section of all the ecologic niches mentioned by Woodring.

Woodring's other great faunal study of the Gatun fauna in Panama (1957-1982) has yielded only 369 species. Dockery's studies of the Vicksburg Group (1982; MacNeil and Dockery, 1984), which includes more than one formation as well as varied ecologies, has a total of 555 species.

In the Recent western Atlantic, Warmke and Abbott (1961) cited 858 species from Puerto Rico, of which 437 are shelled gastropods. This latter number has been increased to 703 by Ortiz-Corps (1985); a comparable increase in the entire fauna indicates a total of 1380 species. Vokes and Vokes (1973) list 796 species from the Yucatan Peninsula, again covering every ecologic niche except the deep-water. David Robinson (pers. comm.) has in preparation a checklist of the Recent mollusks of the Dominican Republic with about 640 species.

When it is finally done, the study in progress on the fossil fauna of the Dominican Republic (Saunders, Jung, Biju-Duval, 1986) will be the most nearly complete of any fauna yet studied (at least, in the Western Hemisphere, the Paris Basin Eocene may surpass it). Just as a measure of comparison, in the Cercado/Gurabo faunal units, representing the shallow and deep water, respectively, I have documented 48 species of muricid (Vokes, 1989); the Chipola and Oak Grove together have 40 muricids.

Thus, our estimate of the Chipola fauna approaches the number of species one might expect in a tropical fauna. In the Chipola Formation we see the reflection of the last truly tropical climatic conditions during the Miocene. The Shoal River Formation, which follows the Chipola, represents a more temperate climate, leading into the distinctly chilly Late Miocene. The Chipola also represents the last major transgression in the western Atlantic, before the lowering of sea-level, due to Late Miocene glaciation. Thus, there are beds of the same age as the Chipola exposed in northeastern Mexico (Guajalote Formation), Panama (La Boca Formation), Venezuela (Cantaure Formation) and the Dominican Republic (Baitoa Formation).

Because of a great similarity of facies, there is a marked resemblance of the Chipola fauna to that of the somewhat younger beds in the Aquitaine Basin of France and the Vienna Basin, as has been noted in previous papers, and one can only wonder at the mechanism of transportation.

This paper has dealt only with the mollusk fauna but other groups of invertebrates are equally worthy of study and would show a corresponding richness in terms of both numbers of species and numbers of individuals.

LITERATURE CITED

AKERS, W. H., 1972, Planktonic foraminifera and biostratigraphy of some Neogene formations, northern Florida and Atlantic Coastal Plain: Tulane Stud. Geol. Paleont., v. 9, p. 1-139, pls. 1-60, 4 figures, 1 map.

COOKE, C. W., 1945, Geology of Florida: Florida Geol. Surv., Geol. Bull. 29, 339 p., 47 text-figs., 1 map.

DALL, W. H., and JOSEPH STANLEY-BROWN, 1894, Cenozoic Geology along the Apalachicola River: Geol. Soc. Amer., Bull., v. 5, p. 147-170, 1 pl., 3 text-figs.

DOCKERY, D.T., III, 1982, Lower Oligocene Bivalvia of the Vicksburg Group in Mississippi: Mississippi Dept. Nat. Res., Bur. Geol., Bull. 123, 261 p., 62 pls. + appendix of 15 pls., 1 table, 48 text-figs.

DREZ, P. E., 1981, Olivinae (Mollusca:Gastropoda) from the Alum Bluff Group of northwestern Florida: Tulane Stud. Geol. Paleont., v. 16, no. 3, p. 105-122, pls. 1,2.

GARDNER, JULIA, 1926-1950, The molluscan fauna of the Alum Bluff Group of Florida: U. S. Geol. Surv., Prof. Paper 142 (in 9 parts), 709 p., 62 pls.

GERTMAN. R. L., 1969, Cenozoic Typhinae (Mollusca:Gastropoda) of the western Atlantic region: Tulane Stud. Geol. Paleont., v. 7, no. 4, p. 143-191, pls. 1-8, 3 text-figs.

HOERLE, S. E., 1972, Cerithiidae and Potamididae (Mollusca:Gastropoda) from the Chipola Formation of northwestern Florida: Tulane Stud. Geol. Paleont., v. 10, no. 1, p. 1-22, pls. 1, 2.

HOERLE, S. E., 1976, The genus *Conus* (Mollusca:Gastropoda) from the Alum Bluff Group of northwestern Florida: Tulane Stud. Geol. Paleont., v. 12, no. 1, p. 1-32, pls. 1-5, 3 tables, 1 text-fig.

HOERLE, S.E., and E. H. VOKES, 1978, A review of the volutid genera *Lyria* and *Falsilyria* (Mollusca:Gastropoda) in the Tertiary of the western Atlantic: Tulane Stud. Geol. Paleont., v. 14, no. 3, p. 105-130, pls. 1-5.

MACNEIL, F. S., and D. T. DOCKERY, III, 1984, Lower Oligocene Gastropoda, Scaphopoda, and Cephalopoda of the Vicksburg Group in Mississippi: Mississippi Dept. Nat. Res., Bur. Geol., Bull. 124, 415 p., 72 pls., 16 text-figs.

MAURY, C. J., 1910, New Oligocene [Miocene] shells from Florida: Bulls. Amer. Paleontology, v. 4, no. 21, p. 119-164, pls. 18-26.

OLSSON, A. A., 1967, Some Tertiary mollusks from south Florida and the Caribbean. Paleontological Research Inst., Ithaca, New York. 61 p., 9 pls.

ORTIZ-CORPS, EDGARDO, 1985, An annotated checklist of the Recent marine Gastropoda (Mollusca) from Puerto Rico: Univ. Puerto Rico, Huamacao Univ. College., Dept. of Biology, 220 p.

PURI, H. S., and R. O. VERNON, 1964, Summary of the Geology of Florida and guidebook to the classic exposures: Florida Geol. Surv., Spec. Publ. 5, ix +311 p., 11 pls., 4 tables, 37 text-figs.

SAUNDERS, J. B., PETER JUNG, and BERNARD BIJU-DUVAL, 1986, Neogene Paleontology in the northern Dominican Republic – 1. Field surveys, Lithology, Environment, and age: Bulls. Amer. Paleontology, v. 89, no. 323, p. 1-79, pls. 1-9, 4 tables, 39 text-figs., 4 appendices.

VOKES, E. H., 1963, Cenozoic Muricidae of the western Atlantic region. Part I – *Murex* sensu stricto: Tulane Stud. Geol., v. 1, no. 3, p. 93-123, pls. 1-4.

VOKES, E. H., 1964, The genus *Turbinella* (Mollusca:Gastropoda) in the New World: Tulane Stud. Geol., v. 2, no. 2, p. 39-68, pls. 1-3, 1 table, 1 text-fig.

VOKES, E. H., 1965, Cenozoic Muricidae of the western Atlantic region. Part II - *Chicoreus* sensu stricto and *Chicoreus (Siratus):* Tulane Stud. Geol., v. 3, no. 4, p. 181-204, pls. 1-3, 2 text-figs.

VOKES, E. H., 1966, The genus *Vasum* (Mollusca:Gastropoda) in the New World: Tulane Stud. Geol., v. 5, no. 1, p. 1-36, pls. 1-6, 1 table, 2 text-figs.

VOKES, E. H., 1967, Cenozoic Muricidae of the western Atlantic region. Part III – *Chicoreus (Phyllonotus):* Tulane Stud. Geol., v. 5, no. 3, p. 133-166, pls. 1-6, 1 table.

VOKES, E. H., 1968, Cenozoic Muricidae of the western Atlantic region. Part IV – *Hexaplex* and *Murexiella:* Tulane Stud. Geol., v. 6, no. 3, p. 85-126, pls. 1-8, 1 text-fig.

VOKES, E. H., 1970a, Cenozoic Muricidae of the western Atlantic region. Part V – *Pterynotus* and *Poirieria:* Tulane Stud. Geol. Paleont., v. 8, no. 1, p. 1-50, pls. 1-7, 1 text-fig.

VOKES, E. H., 1970b, Notes on the fauna of the Chipola Formation – III. Two new species of *Vasum* (Mollusca:Gastropoda), with comments on *Vasum haitense* (Sowerby): Tulane Stud. Geol. Paleont., v. 8, no. 2, p. 88-92, pl. 1.

VOKES, E. H., 1972a, Notes on the fauna of the Chipola Formation – VI. On the ocurrence of *Pterynotus pinnatus* (Gastropoda:Muricidae) and the problems of dispersal: Tulane Stud. Geol. Paleont., v. 10, no. 1, p. 29-30, 2 text-figs.

VOKES, E. H., 1972b, Notes on the fauna of the Chipola Formation – VII. On the occurrence of the genus *Concholepas* (Gastropoda:Thaididae), with the description of a new species: Tulane Stud. Geol. Paleont., v. 10, no. 1, p. 31-33, 1 text-fig.

VOKES, E. H., 1974a, Notes on *Chicoreus* (Mollusca:Gastropoda) from the Cenozoic of the western Atlantic region, with the description of new species: Tulane Stud. Geol. Paleont., v. 11, no. 2, p. 81-95, pls. 1-3.

VOKES, E. H., 1974b, Notes on the fauna of the Chipola Formation – XV. On the occurrence

of *"Ranella" poppelacki* Hörnes, a gastropod of uncertain affinities: Tulane Stud. Geol. Paleont., v. 11, no. 2, p. 96-98, 2 text-figs.

VOKES, E. H., 1975a, Cenozoic Muricidae of the western Atlantic region. Part VI – *Aspella* and *Dermomurex:* Tulane Stud. Geol. Paleont., v. 11, no. 3, p. 121-162, pls. 1-6, 2 tables, 1 text-fig.

VOKES, E. H., 1975b, Notes on the fauna of the Chipola Formation – XVII. Some new or otherwise interesting members of the Calyptraeidae (Mollusca: Gastropoda): Tulane Stud. Geol. Paleont., v. 11, no. 3, p. 163-172, pls. 1, 2; 5 text-figs.

VOKES, E. H., 1989, Neogene Paleontology in the northern Dominican Republic; 8: The Family Muricidae (Mollusca:Gastropoda): Bulls. Amer. Paleontology, v. 97, no. 332, 245 MS pp., 12 pls., 21 text-figs.

VOKES, E. H., and ROLAND HOUART, 1986, An evaluation of the taxa *Muricopsis* and *Risomurex* (Gastropoda:Muricidae), with one new species of *Risomurex:* Tulane Stud. Geol. Paleont., v. 19, no. 2, p. 63-88, pls. 1-4.

VOKES, E. H., and ANTHONY D'ATTILIO, 1980, *Pygmaepterys*, a newly described taxon of Muricidae (Mollusca:Gastropoda), with the description of three new species from the Cenozoic of the western Atlantic: Tulane Stud. Geol. Paleont., v. 16, no. 2, p. 45-54, pls. 1, 2; 1 text-fig.

VOKES, H. E., 1969a, Observations on the genus *Miltha* (Mollusca:Bivalvia) with notes on the type and Florida Neogene species: Tulane Stud. Geol. Paleont., v. 7, no. 3, p. 93-126, pls. 1-7, 3 text-figs.

VOKES, H. E., 1969b, Notes on the fauna of the Chipola Formation – I. A new species of *Eomiltha* (Mollusca:Bivalvia): Tulane Stud. Geol. Paleont., v. 7, no. 3, p. 126-130, pl. 1.

VOKES, H. E., 1973, Notes on the fauna of the Chipola Formation – XIII. The family Limidae (Mollusca:Bivalvia): Tulane Stud. Geol. Paleont., v. 10, no. 2, p. 87-96, pl. 1, 3 tables.

VOKES, H. E., 1977a, Cardiidae (Mollusca,Bivalvia) from the Chipola Formation, Calhoun County, Florida: Tulane Stud. Geol. Paleont., v. 13, no. 4, p. 143-189, pls. 1-10, 6 tables, 1 text-fig.

VOKES, H. E., 1977b, Notes on the fauna of the Chipola Formation – XXI. A new species of the genus *Lopha* (Mollusca:Bivalvia): Tulane Stud. Geol. Paleont., v. 13, no. 4, p. 190-191, 8 text-figs.

VOKES, H. E., 1982, Notes on the fauna of the Chipola Formation – XXVI. A new species of *Trachycardium* from Tenmile Creek: Tulane Stud. Geol. Paleont., v. 17, no. 2, p. 55-56, 1 text-fig.

VOKES, H. E., 1986, Mytilidae (Mollusca:Bivalvia) from the Chipola Formation, Lower Miocene, Florida: Tulane Stud. Geol. Paleont., v. 19, no. 4, p. 159-173, pls. 1, 2; 1 table.

VOKES, H. E., and E. H. VOKES, 1983, Distribution of shallow-water marine Mollusca, Yucatan Peninsula, Mexico: MesoAmer. Ecol. Inst., Mon. 1 (Midd. Amer. Resh. Inst., Publ. 54), 183 p., 50 pls., 9 text-figs., 3 tables, 1 map.

WARMKE, G. L., and R. T. ABBOTT, 1961, Caribbean Seashells. Narberth, Pennsylvania. x + 348 p., 44 pls., 34 text-figs., 19 maps and end papers.

WOODRING, W. P., 1925, Miocene mollusks from Bowden, Jamaica; Pelecypods and Scaphopods: Carnegie Inst. Washington, Publ. 366, vii + 222 p., 28 pls.

WOODRING, W. P., 1928, Miocene mollusks from Bowden, Jamaica; part 2, Gastropods and discussion of results: Carnegie Inst. Washington, Publ. 385, 564 p., 40 pls.

WOODRING, W. P., 1957-1982, Geology and paleontology of Canal Zone and adjoining parts of Panama: U. S. Geol. Surv., Prof. Paper 306 (in 6 parts), 759 p., 124 pls., 5 text-figures, 1 map.

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AN UNUSUAL ADDITION TO THE MURICIDAE (MOLLUSCA;GASTROPODA) OF THE ESMERALDAS BEDS, NORTHWESTERN ECUADOR

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A visit to the British Museum (Natural History) by William and Lois Pitt, of Sacramento, California, for the purpose of examining the material in their collections from the Tertiary beds of coastal Ecuador, disclosed a most unusual addition to the muricid fauna of the Esmeraldas Beds, near Quebrada Camarones (locality TU 1397), which is on the northwestern coast about 10 km east of the mouth of the Rio Esmeraldas. Having just published a study of the muricid fauna of this area (Vokes, 1988), wherein I noted that three of the 21 species of Muricidae occurring in these beds have a closer affinity to species living in northern California or Japan than to anything in the waters of tropical America, it is especially gratifying to recognize this new species as another relative of the Japanese fauna.

But this new species is not just another muricid to add to the fauna, it is the third representative, and the first outside of Japan, of a most unusual genus that lives parasitically upon pectens, as has been well documented by Matsukuma (1977). The Japanese species, *Genkaimurex varicosus* (Kuroda, 1953), although originally described as *Coralliophila,* a genus characterized by having no radula, has a typical rachiglossate radula that it utilizes to bore neat round holes in the shell of the pecten through which it sucks enough of the clam's juices to nourish the gastropod but not to damage the host. Thus, it is a true case of parasitism.

Recent examples of *Genkaimurex varicosus* live in depths of 45 m (the type) to 94 m (Matsukuma, 1977, p. 82). The second species of *Genkaimurex, G. fimbriatulus* (A. Adams) was described from 88-100 m (48-55 fms, *fide* Adams, 1863, p. 375) and the specimen figured here is from 108 m, so that 100 m seems to be the approximate depth that this group inhabits. This fits well with the the environment of deposition for the mollusks at Quebrada Camarones, which is relatively shallow-water material that has been carried down into depths of as much as 1000 m. In my previous discussion I noted that the slide at TU 1397 began in depths on the order of 75 m, then was washed out into the deeper water (Vokes, 1988, p. 8).

As was also discussed in the previous paper, the beds at Quebrada Camarones have been referred to the Onzole Formation by workers in the area but the nature of these highly fossiliferous beds, which have been deposited into the deep-water clays of the true Onzole Formation, are so lithologically distinctive that I prefer to retain the informal usage of "Esmeraldas Beds" for the fossil-rich layers found in the upper portions of the Onzole Formation, which have been dated as Early Pliocene (N 18-19) by Haman and Kohl (1986, p. 181).

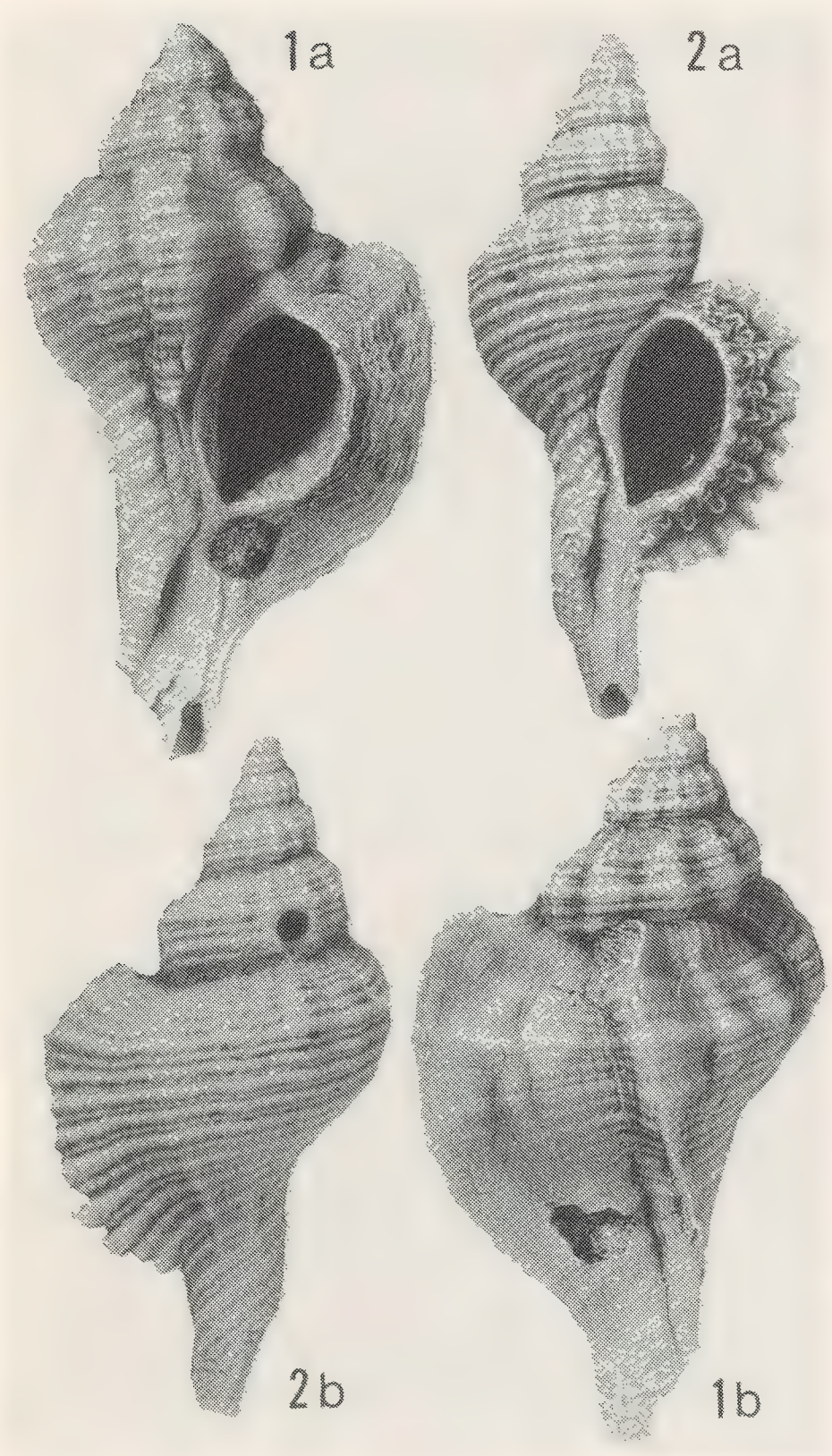
Family MURICIDAE Rafinesque, 1815
Subfamily THAIDINAE Jousseaume, 1888
Genus GENKAIMUREX Kuroda, 1953

Genkaimurex KURODA, 1953, Venus, Japanese Jour. Malac., v. 17, no. 3, p. 120.

Type species: *Coralliophila (Genkaimurex) varicosa* Kuroda, by original designation.

GENKAIMUREX AMERICANUS Vokes, n. sp.
Text-figure 1

Description: High-spired shell with early whorls damaged and plugged by animal. On earliest whorl (of the five preserved) spiral ornamentation of three cords, all of the same strength. Weaker cords intercalated on later whorls, so the penultimate has five stronger cords alternating with weaker ones; the cord at the periphery somewhat stronger than the two pairs on either side. Sub-sutural ramp almost smooth. On body whorl spiral ornamentation weakening but still of alternating stronger and weaker cords, approximately 12 of each. On first post-nuclear whorl preserved axial ornamentation of 12 faint ridges, becoming increasingly stronger with each whorl. On body whorl four varices developed, only that at the aperture more than just a slightly enlarged axial ridge. Between each pair of varices two indistinct intervarical nodes. Aperture rounded, inner lip smooth, narrow, appressed the entire length; outer lip slightly crenulated, with four small denticles on anterior portion of inner side. Terminal varix formed by multiple layers of shelly material on the adapertural face, crenulated in accord with the outer spiral cords. Siphonal canal long, straight, sealed over by shelly plates extending from either side and meeting along the mid-line.



Text-figure 1. *Genkaimurex americanus*, n. sp.; BMNH GG 21981 (holotype); height 26.2 mm, diameter 14.7 mm; locality CRB 284 (X 2). Text-figure 2. *Genkaimurex fimbriatulus* (Adams); USNM 205480; height 16.5 mm, diameter 8.5 mm; locality Korea Straits, Japan, 108 m (X 2).

Holotype: British Museum (Natural History) Palaeontology Dept. No. GG 21981; height 26.3 mm, diameter 14.7 mm.

Type locality: Esmeraldas Beds, Onzole Formation, CRB locality 284, on coast of northwestern Ecuador; Lat. 0°50′N, Long. 79°34′W. Collected by C. R. Bristow and J. W. Whittaker, November, 1974.

Occurrence: Esmeraldas Beds, Onzole Formation, Ecuador.

Discussion: This new species is more closely related to the second Japanese species of *Genkaimurex*, *G. fimbriatulus* (Adams) than it is to the type of the genus. The type, *G. varicosus* has a low-spired shell with a deeply channeled suture, giving the whorls a very inflated appearance. D'Attilio (1978, p. 37) placed the two Japanese species in synonymy but noted that the illustration given by Matsukuma (1977, text-fig. 2B) for the protoconch of *G. varicosus* was different from that given by him (D'Attilio, 1978, text-fig. 3) for *G. fimbriatulus*. This is correct, *G. varicosus* has a protoconch of one and one-half smooth whorls, as shown by Matsukuma, and *G. varicosus* has a strongly keeled protoconch, as shown by D'Attilio. It is obvious that the two are different species.

Although most similar to *G. fimbriatulus*, the new species is easily distinguished from the Japanese form by the development of four varices on the body whorl. So far as is known, specimens of *G. fimbriatulus* do not ever develop any varices except the terminal one. However, *C. varicosus* does develop these extra varices in fully adult specimens, and the Ecuadorian species is somewhat intermediate in shape between the high-spired *G. fimbriatulus* and the low-spired *G. varicosus*. Neither of the Japanese species have the denticles on the inner side of the outer lip that are seen in *G. americanus*.

I would like to thank the Department of Palaeontology, British Museum (Natural History) for the loan of the type specimen.

LITERATURE CITED

ADAMS, ARTHUR, 1863, On the species of Muricinae found in Japan: Zool. Soc. London, Proc. for 1862, p. 370-376.

D'ATTILIO, ANTHONY, 1978, Notes on *Genkaimurex fimbriatulus* (A. Adams, 1862): The Festivus, v. 10, no. 5, p. 37-38, 4 text-figs.

HAMAN, DREW, and BARRY KOHL, 1986, Early Pliocene *Montfortella* (Foraminiferida) from Ecuador: Tulane Stud. Geol. Paleont., v. 19, no. 4, p. 181-183, 1 pl.

MATSUKUMA, AKIHIKO, 1977, Notes on *Genkaimurex varicosa* (Kuroda, 1953) (Prosobranchia:Neogastropoda): Venus, Japanese Jour. Malac., v. 36, no. 2, p. 81-88, 1 pl., 1 text-fig.

VOKES, E. H., 1988, Muricidae (Mollusca:Gastropoda) of the Esmeraldas Beds, northwestern Ecuador: Tulane Stud. Geol. Paleont., v. 21, no. 1, p. 1-50, pls. 1-6, 13 text-figs., 1 table.

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STRATIGRAPHIC NOTES

THE CLAYTON FORMATION (PALEOCENE) OF ALABAMA

I. ON THE CLAYTON FORMATION LITHOSTRATOTYPE

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ABSTRACT

A recently published measured section of the lithostratotype of the Paleocene Clayton Formation at Clayton, Barbour County, Alabama, interpreted the Clayton Formation as consisting primarily of crystalline limestone. A measured section interpreting the type Clayton as a section of calcareous sands with a prominent black clay bed is presented here. It is suggested that the carbonate section may actually have been to the southeast of the lithostratotype, where a carbonate facies does predominate.

A recent paper by Reimers (1986) describing the calcareous nannoplankton of the Paleocene Midway Group of Alabama is the first comprehensive treatment of the Paleocene calcareous nannoplankton in the eastern Gulf Coastal Plain. This, plus the detailed taxonomic descriptions and excellent illustrations of the flora, marks this study as an important milestone in the biostratigraphy of the eastern Gulf Coast Paleocene.

Upon examination of the description of the twelve sections studied by Reimers, an inconsistency is apparent in the description and illustration of the Clayton Formation lithostratotype (Reimers, 1986, p. 6, fig. 8). The described section is shown as consisting of approximately 23 feet (7 meters) of limestone with basal sand and clay units. This description is very different from that described by Reinhardt and Gibson (1980) and that presented by Fluegeman (1986). The Clayton Formation type section did not produce calcareous nannofossils for Reimers and, thus, it did not play a critical role in that investigation. As it is the most recent published description of the Clayton lithostratotype, however, the discrepancy in published descriptions of the type section is potentially confusing. Furthermore, the Clayton Formation is one of the most widely recognized units in the Gulf Coastal Plain, occurring from southern Illinois to western Georgia. If consistency in application of the name Clayton to Paleocene lithofacies is to be obtained, a firm idea of what the Clayton Formation is like at its lithostratotype is essential. It is the intent of this paper to present a revised interpretation of the Clayton Formation type section of Reimers.

The Clayton Formation lithostratotype is located in a cut of the Central of Georgia Railroad, 1.6 km east of the town of Clayton, Barbour County, Alabama and immediately north of the intersection of County Road 28 and the railroad (Clayton North 7-1/2' Quadrangle, section 34, T11N, R36E). The measured section is illustrated in Figure 1.

The Clayton Formation lithostratotype consists of 7.1 meters of sand, local limestones, and a unit of dark gray to black clay in the middle part of the section. The measured section described here is similar to that of Reinhardt and Gibson (1980). The section was sampled for microfossils producing several assemblages of benthic foraminifera (Fluegeman, 1986).

The difference between the measured section of the Clayton Formation lithostratotype presented here and the section of Reimers is striking. Reimers describes and illustrates a section that is primarily limestone and the section presented here is mostly sand with local limestone and clay beds.

Lithologically, the Clayton Formation measured and described by Reimers resembles the Clayton lithology at Town Creek in Fort Gaines, Clay County, Georgia (Marsalis and Friddell, 1975). This section is within 50 km of the Clayton type section but represents a greatly different lithofacies. The transition between the clastic and carbonate facies is far from clear cut. A question arises: As the precise location of the transition between carbonate and clastic facies is unknown, might the section of Reimers be a local development or extension of the carbonate facies into the area around Clayton? This seems unlikely, as the location of his measured

section is very specific and matches that of other workers.

A second possibility for the difference in measured sections could simply be due to field interpretation. The calcareous sands with local limestones identified in this paper and by Reinhardt and Gibson could have been interpreted as sandy limestones in the field and the proportion of local limestone beds in the section could have been overestimated. Were this true, the measured section of Reimers would still have contained the one meter thick dark gray to black clay bed, the conspicuous "leaf clay."

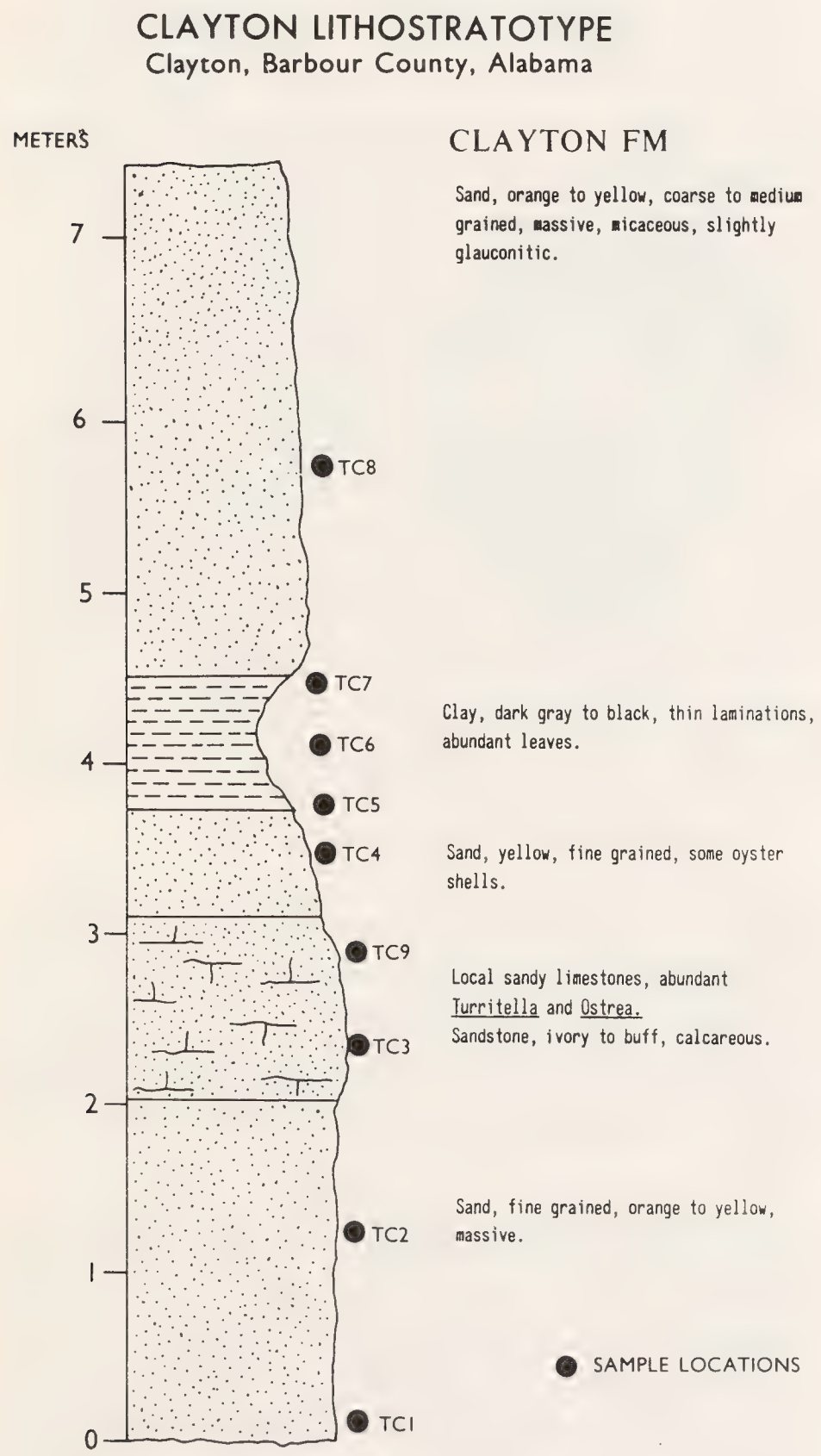

Figure 1. Measured section of the Clayton Formation lithostratotype. Sample locations are those used by Fluegeman (1986). Section measured by R. H. Fluegeman and K. Brabender.

It is suggested here that the section illustrated and described by Reimers is not the Clayton Formation lithostratotype but is a section from within the carbonate facies of the Clayton east of the type area. The precise location of such a section would prove valuable to studies of lithofacies relationships within the Clayton Formation, as it may extend the carbonate facies of the Clayton farther to the west than presently recognized.

Furthermore, since the Clayton Formation lithostratotype was not sampled for calcareous nannofossils by Reimers, an examination of this section may provide valuable information. Although Bybell (1980) reported no calcareous nannofossils from this section, the recovery of benthic foraminifera by Fluegeman demonstrates that the Clayton Formation lithostratotype does contain calcareous microfossils and should be re-examined for calcareous nannofossils.

LITERATURE CITED

BYBELL, L. M., 1980, Paleogene calcareous nannofossils *in* REINHARDT and GIBSON, Upper Cretaceous and Lower Tertiary geology of the Chattahoochee River Valley, western Georgia and eastern Alabama: *in* R. W. FREY (ed.), Excursions in Southeastern Geology, p. 416-420.

FLUEGEMAN, R. H., JR., 1986, Foraminifera from Paleocene Clayton Formation lithostratotype, Barbour County, Alabama (abs.): Bull. Amer. Assoc. Petrol. Geol., v. 70, p. 591.

MARSALIS, W. E., and M. S. FRIDDELL, 1975, A guide to selected Upper Cretaceous and Lower Tertiary outcrops in the Lower Chattahoochee River Valley of Georgia: Georgia Geol. Surv., Guidebook 15.

REIMERS, D. D., 1986, The calcareous nannoplankton of the Midway Group (Paleocene) of Alabama: Tulane Stud. Geol. Paleont., v. 19, p. 1-49.

REINHARDT, J., and T. G. GIBSON, 1980, Upper Cretaceous and Lower Tertiary geology of the Chattahoochee River Valley, western Georgia and eastern Alabama: *in* R. W. FREY (ed.), Excursions in Southeastern Geology, p. 385-464.

II. DISCUSSION OF THE TYPE SECTION OF THE CLAYTON FORMATION OF ALABAMA

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Fluegeman (1989) describes a lithologic section consisting of sands and clays as the lithostratotype of the Clayton Formation of Alabama, rather than a predominantly limestone section as described by Reimers (1986) (figure 1). The section given by Fluegeman contains only a single one meter unit of limestone and seems to be the same section described by Reinhardt and Gibson (1980) (figure 2). Any section that is termed a lithostratotype or type section must be compared to the original type section, as described by the original author. In order to resolve which section (that of Reimers or Fluegeman) is the type section, the original type description was consulted. Neither Fluegeman (1989) or Reinhardt and Gibson refer to the original reference or any other early descriptions of the type Clayton.

In Smith *et al.* (1894) the lowermost Tertiary near Clayton, Alabama, is named the Clayton Limestone. This reference states that the section is in a railroad cut near Clayton and is described as ten to fifteen feet of dark blue, nearly black clays overlying five to six feet of limestone. The exact location is not given. Smith *et al.* further describe the limestone as a hard, almost crystalline limestone with grains of quartz. Reimers' section (figure 1) shows a tan, massive limestone unit 16 feet (4.9 m) thick with thinner sand and clay units at the bottom. The upper portion of Reimers' section was covered. The Fluegeman and Reinhardt and Gibson sections show only a one meter unit of sandy limestone within the section. Both make mention of a thin clay bed with abundant leaves. Smith *et al.* make no mention of this bed in the original description.

Other references also describe a section of limestone as being a typical Clayton section or as a type section (MacNeil 1946, Cooke 1926, Hastings and Toulmin, 1963, etc.) These include field trip guidebooks as well as reports on the geology and stratigraphy of Alabama. The Alabama Geological Survey regards the limestone section as being the typical section of the Clayton Formation and closer in description to the original section than any other exposures (Mancini, personal communication).

Further clarification of the location and description of a type section of the Clayton is provided by the Gulf Coast Association of Geological Societies' (1970) type localities project. In the type locality description of the Clayton Formation, the type locality is given as that described by Smith *et al.* This is the railroad cut east of Clayton. The section given by this project is shown in figure 3, which shows the Clayton as sand overlain by massive fine

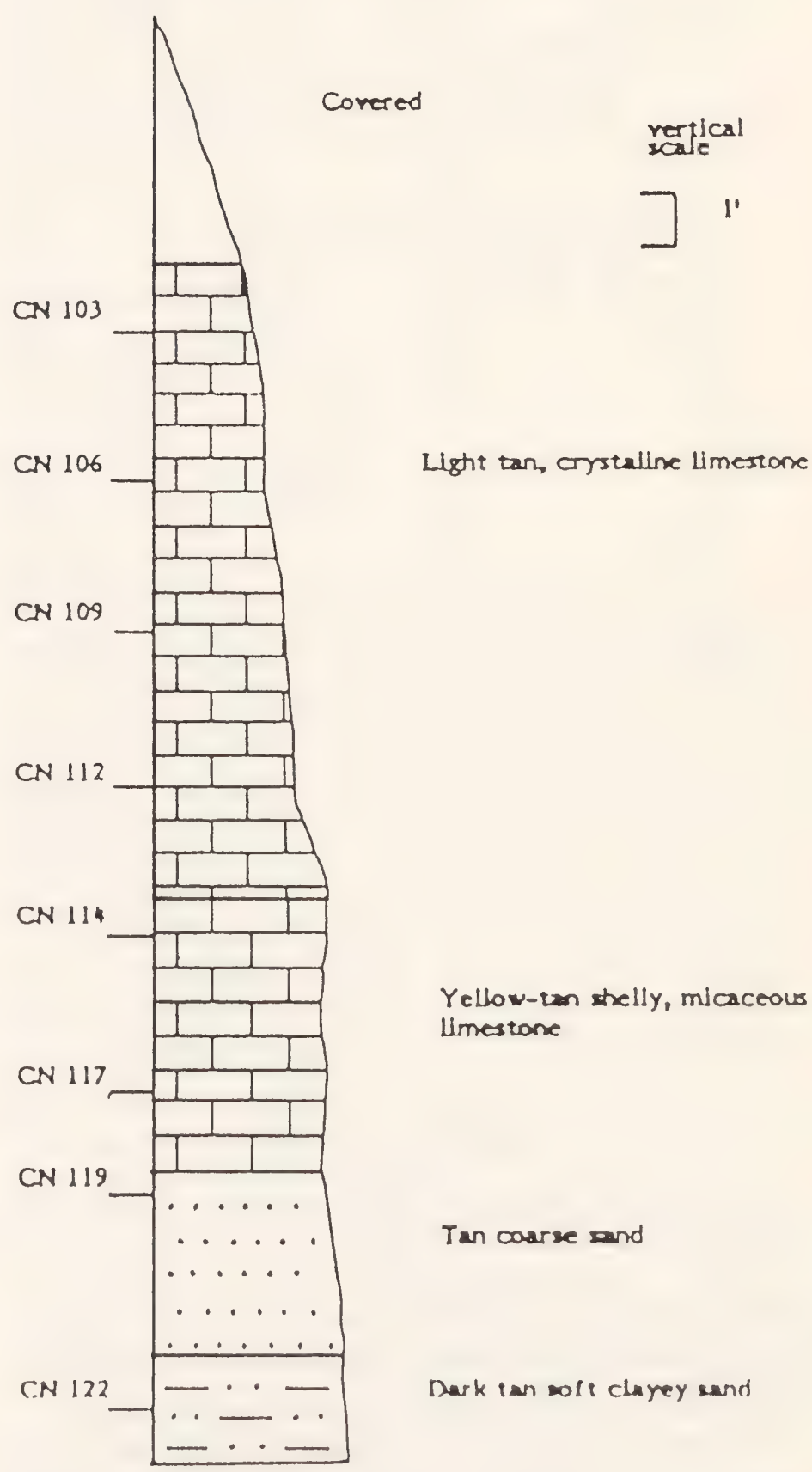

Figure 1. Stratigraphic section of the Clayton Formation. (From Reimers, 1986).

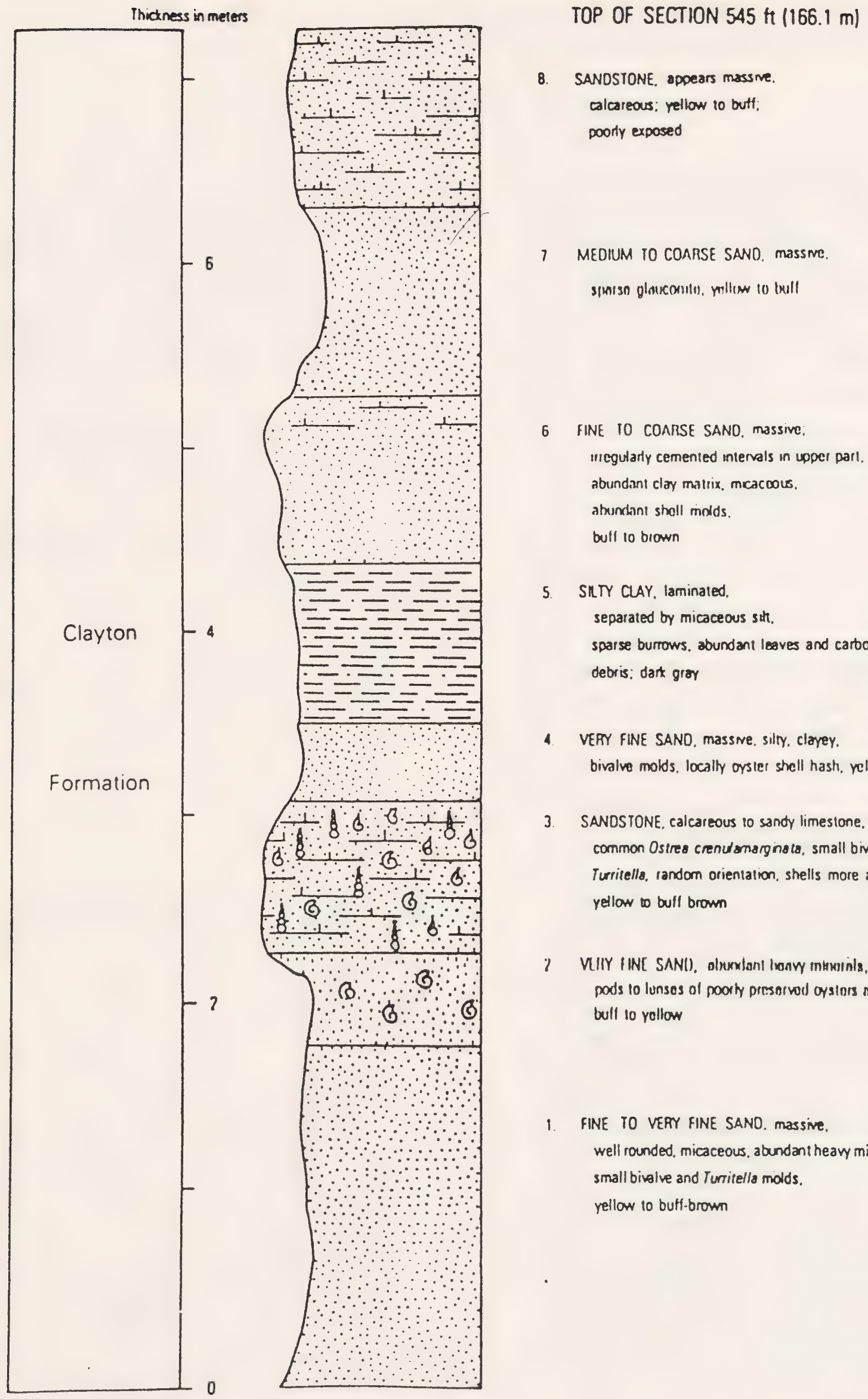

Figure 2. Stratigraphic section of the Clayton Formation. (From Reinhardt and Gibson, 1980).

sandy limestone. This description is similar to that of Reimers, and unlike that of Fluegeman or Reinhardt and Gibson.

Figure 4 shows the entire GCAGS type locality project map and sections. Note the second section, which is northeast of the typical limestone section of the Clayton. This second section is very similar to the Fluegeman section, including a thin limestone unit and a siltstone unit containing leaves. This figure shows the limestone unit as Clayton and the second section as Nanafalia Formation resting above an unconformity on the Clayton. This unconformity may have been overlooked by Fluegeman and Reinhardt and Gibson, if

Railroad cut in NW¼, NW¼,

Sec. 3, T10N, R26E.

Figure 3. Stratigraphic section of the Clayton Formation. (From Gulf Coast Association of Geological Societies, 1970).

this is the same section as that described by them. Regardless of the unit name assigned to the second section, this sequence cannot be regarded as the type section of the Clayton Formation, because the type section was originally described as containing a thick limestone unit. Since the exact location of the original limestone section is not known, a section as similar as possible to the type locality must be used as the reference section for the Clayton. Though the Reimers, Fluegeman, and Reinhardt and Gibson sections are in the type locality area, the Reimers section must be the reference section, based on these facts: 1) it contains the massive limestone described in the original reference by Smith *et al.;* 2) it is the same section described by the GCAGS type section project; 3) it is used by the Alabama Geological Survey as the reference section; and 4) it is close in description to the Clayton Formation sections as given in other references.

With the type section then containing a limestone unit and such a unit being described by Reimers and the GCAGS, the question must be answered as to which stratigraphic unit the Fluegeman, Reinhardt and Gibson, and the second GCAGS sections belong. If the three are the same or at least in close proximity to one another, they can be Nanafalia as given in the GCAGS project. A more plausible explanation can be found in Cooke (1926). In a description of the Cenozoic beds of Alabama, the Clayton is described as clay, sandy limestone, and limestone; however, all gradations from hard limestone through sandy limestone and calcareous sandstone to loose quartz sand are found. The change from limestone to sand may take place within a few feet either up or down or sideways. Adams (personal communication) concurs with the observation that the sandstone sections can be seen to develop over short lateral dis-

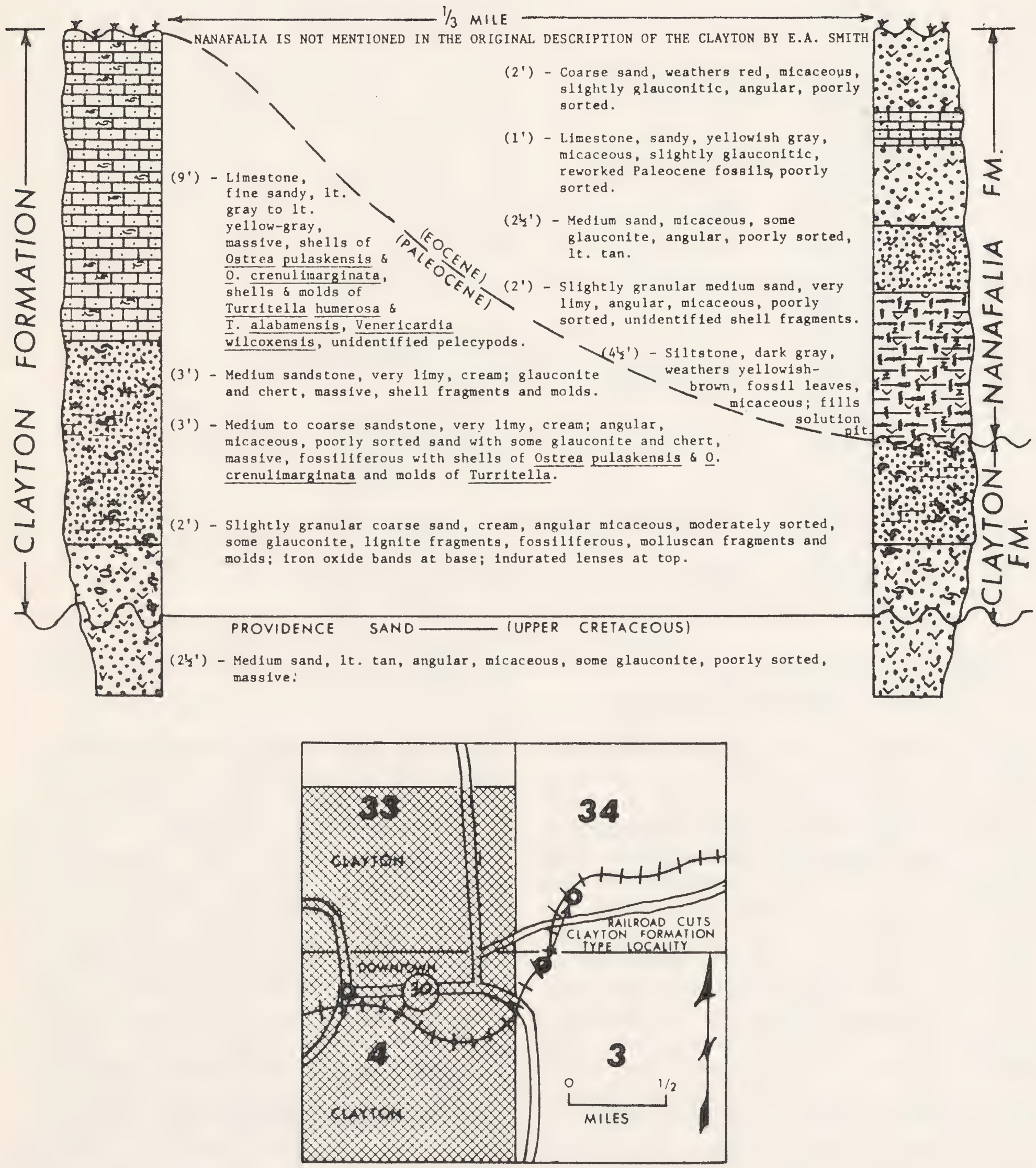

Figure 4. Map and two stratigraphic sections of the Clayton Formation. (From Gulf Coast Association of Geological Societies, 1970).

tances. The Fluegeman section is probably a sandy facies of the Clayton, with the section given by Reimers the equivalent of the limestone described in the original type reference and, thus, it must serve as a lithostratotype rather than any of the sand/clay sections.

LITERATURE CITED

COOKE, C. W., 1926, The Cenozoic Formations *in* G. I. ADAMS, C. BUTTS, L. W. STEPHENSON, and C. W. COOKE, Geology of Alabama: Geol. Surv. Alabama, Spec. Rept. 14, p. 251-297.

GULF COAST ASSOCIATION OF GEOLOGICAL SOCIETIES, 1970, Clayton Formation (Paleocene), type locality descriptions: Trans., Gulf Coast Assoc. Geol. Soc., 20th Ann. Mtg., 1970, p. 320-321.

FLEUGEMAN, R. H., JR., 1989, On the Clayton Formation lithostratotype: Tulane Stud. Geol. Paleont., v. 22, p. 27-28.

HASTINGS, E. L., and L. D. TOULMIN, 1963, Summary of Paleocene and Eocene stratigraphy and economic geology of southeastern Alabama: 10th Ann. Field Trip, Southeastern Geological Society, p. 1-31.

MACNEIL, F. S., 1946, The Tertiary Formations of Alabama: Southeastern Geological Society, 4th Ann. Field Trip, Southeastern Alabama, p. 1-91.

REIMERS, D. D., 1986, The calcaerous nannoplankton of the Midway Group (Paleocene) of Alabama: Tulane Stud. Geol. Paleont., v. 19, p. 1-49, 14 plates, 23 text figs.

REINHARDT, J., and T. G. GIBSON, 1980, Upper Cretaceous and Lower Tertiary geology of the Chattahoochee River Valley, western Georgia and eastern Alabama: *in* R. W. FREY (ed.), Excursions in Southeastern Geology, p. 431-463.

SMITH, E. A., L. C. JOHNSON, and D. W. LANGDON, JR., 1894, Report on the geology of the Coastal Plain of Alabama, with contributions to its paleontology by T. H. Aldrich and K. M. Cunningham: Alabama Geol. Surv., Spec. Rept. 6, 704 p., 29 pls.

III. THE TYPE SECTION OF THE CLAYTON FORMATION OF ALABAMA: A REPLY

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I am very grateful to David D. Reimers for the discussion of my paper (Fluegeman, 1989) on the Clayton Formation lithostratotype. It is clear from his discussion and from my own work that there is some ambiguity as to the interpretation of the type section of the Clayton Formation. I wish to address a few points raised by Reimers about the type section of the Clayton Formation.

The purpose of my paper was to point out what I considered a discrepancy in the type section of the Clayton Formation described by Reimers (1986) when compared with the section designated as the lithostratotype of the Clayton Formation by Reinhardt and Gibson (1980). A full literature review of the Clayton Formation was not included in that paper, as I considered the section I used to be clearly the type section. My conclusion was based on the early work as well as the data presented by Reinhardt and Gibson (1980) from a nearby corehole.

The first use of the name Clayton was not Smith *et al.* (1894), as reported by Reimers, but by Langdon (1891). This study does not, however, shed any light on the nature of the Clayton Formation away from the Chattahoochee Valley. Smith *et al.* do provide a description of a section in the railroad cut near Clayton but it includes 10 to 15 feet (3 to 4.5 m) of clay overlying 5 to 6 feet (1.5 to 1.8 m) of limestone. The upper portion of this section must be the clay unit designated as the Porters Creek outlier by Reinhardt and Gibson, and as such, the Clayton Formation described by Smith *et al.* includes only the upper part of the Clayton Formation. The section of the Clayton Formation described by MacNeil (1946) appears to include the section described by Smith *et al.* but adds a section of sands and some limestones below it.

As anyone who has visted the railroad cut at Clayton knows, there are two railroad cut sections. Despite the assertion of Reimers that the section south of the railroad crossing was designated by the Gulf

Coast Association of Geological Societies (1970) as the type section of the Clayton Formation, both sections were included. The unconformity in the cut north of the railroad crossing, at the base of the "leaf clay," proposed in the GCAGS section is not obvious and is not supported by dinoflagellate assemblages (Edwards, 1980). Thus, the possibility that this section is actually in the Nanafalia Formation seems remote and it appears that both sections are within the Clayton Formation. The southern section does represent a higher portion of the Clayton than does the northern section, based on hand level measurements and the presence of the "leaf clay" at the base of the southern section. It appears that both sections at Clayton complement each other and are worthy of study.

Which of the two sections is the Clayton Formation lithostratotype? My own conclusion that it is the section north of the railroad crossing is based on the description by MacNeil (1946). Although much of this section is no longer exposed, the base of the Clayton consists of a series of sands and sandy limestones with hard crystalline limestone at the top. Specific thicknesses are not provided but if, as I feel, this section is a continuation of the one described by Smith *et al.*, the crystalline limestone is probably about 5 or 6 feet (1.5 to 1.8 m) thick. When the record of U.S.G.S. corehole 102 (drilled at the top of the hill of which the sections are a part, reported by Reinhardt and Gibson, 1980) is examined, a marked similarity to the described sections of Smith *et al.* and MacNeil is in evidence. This corehole has a slight overlap (perhaps 1 meter) with the northern section. At the top of the hill, there is outcropping sediment and it is reasonable to assume that the section encountered in Core 102 was once exposed on the hill. Certainly the clay in the corehole is the same as that described by Smith *et al.* and MacNeil. From the lower part of Corehole 102, Reinhardt and Gibson report approximately 5 feet (1.5 m) of indurated beds, which could not be cored. My interpretation of this interval is that these indurated beds are the "5 to 6 foot limestone" described by Smith *et al.* directly beneath the clay.

The section south of the railroad crossing does contain limestone but my own field descriptions indicate about 3 m of sandy limestones and calcareous sands overlying calareous sands and a basal clay (the "leaf clay" based on hand level measurements and microscopic examination). This description is close to the description of the Gulf Coast Association of Geological Societies section but does not seem to match the limestone described by Smith *et al.* If the mere presence of limestone makes the southern exposure the type section, where does the described clay fit in? The sections of Smith *et al.* and MacNeil both show a clay, which was assigned by Reinhardt and Gibson to the Porters Creek Formation. In fact, 15 feet (4.5 m) of the 20 feet (6.1 m) described by Smith *et al.* is this clay unit. According to this, and to the MacNeil description, I believe the Clayton was described originally as a unit containing a high proportion of clastic sediment. Furthermore, I feel that the outcrop north of the railroad crossing is the lower part of MacNeil's section and as such is the only remaining outcrop of the Clayton Formation lithostratotype.

LITERATURE CITED

EDWARDS, L. E., 1980, Dinoflagellate biostratigraphy: a first look, *in* R. W. FREY (ed.), Excursions in Southeastern Geology, p. 424-427.

FLUEGEMAN, R. H., JR., 1989, On the Clayton Formation lithostratotype: Tulane Stud. Geol. Paleont., v. 22, p. 27-28.

LANGDON, D. W., 1891, Variations in the Cretaceous and Tertiary strata of Alabama: Geol. Soc. Amer., Bull., v. 2, p. 589-605.

MACNEIL, F. S., 1946, U. S. Geol. Survey, Strategic Minerals Inv., Prelim. Rept. 3-195, p. 6-10.

REIMERS, D. D., 1986, The calcareous nannoplankton of the Midway Group (Paleocene) of Alabama: Tulane Stud. Geol. Paleont., v. 19, p. 1-49.

REINHARDT, J., and T. G. GIBSON, 1980, Upper Cretaceous and Lower Tertiary geology of the Chattahoochee River Valley, western Georgia and eastern Alabama: *in* R. W. FREY (ed.), Excursions in Southeastern Geology, p. 431-463.

SMITH, E. A., L. C. JOHNSON, and D. W. LANGDON, JR., 1894, Report on the geology of the Coastal Plain of Alabama, with contributions to its paleontology by T. H. Aldrich and K. M. Cunningham: Alabama Geol. Surv., Spec. Rept. 6, 704 p., 29 pls.

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PLIOCENE THREE-TOED HORSES FROM LOUISIANA, WITH COMMENTS ON THE CITRONELLE FORMATION

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I. ABSTRACT

Teeth and metacarpals of early Pliocene (latest Hemphillian land-mammal age) three-toed (hipparionine) horses are described from the Tunica Hills of West Feliciana Parish in east-central Louisiana. An upper molar pertains to *Nannippus minor*, known from the Hemphillian of Central and North America, and two teeth and two distal metacarpals pertain to a recently described species of *Cormohipparion*, *C. emsliei*, known only from Pliocene (latest Hemphillian and Blancan land mammal ages) sites in peninsular Florida. The material represents the first record of Pliocene non-marine fossils from Louisiana, as well as the first record of a fossil horse from the state other than Pleistocene *Equus*. Found in surface stream gravels, the horses probably were derived from the otherwise almost nonvertebrate-bearing Citronelle Formation.

II. INTRODUCTION

Fossil land mammals of pre-Pleistocene age are exceedingly rare in Louisiana. In January of 1985, the senior author was shown a large collection of late Pleistocene (Rancholabrean land-mammal age) vertebrate fossils from the Tunica Hills of Louisiana (Fig. 1) by Dr. A. Bradley McPherson of Centenary College, Shreveport. McPherson and Mr. Bill Lee of Baton Rouge had collected fossils from that area since about 1981. Among the standard assemblage of Rancholabrean taxa (*e.g.* mastodon, horse, ground sloth, tapir and bison) were an upper molar and distal metacarpal of very small horses collected by them in 1983, which were quite different from the common large *Equus* of the fauna. In 1986 McPherson and Lee collected two more teeth and another distal metacarpal of a small, primitive horse. These five specimens are, thus far, the only record of a pre-late Pleistocene fauna among the hundreds of vertebrate fossils that have been found in the Tunica Hills area. They indicate the presence of terrestrial or near-shore early Pliocene deposits in Louisiana. The purpose of the present study is to describe this material and to discuss its implications for Louisiana biochronology and stratigraphy.

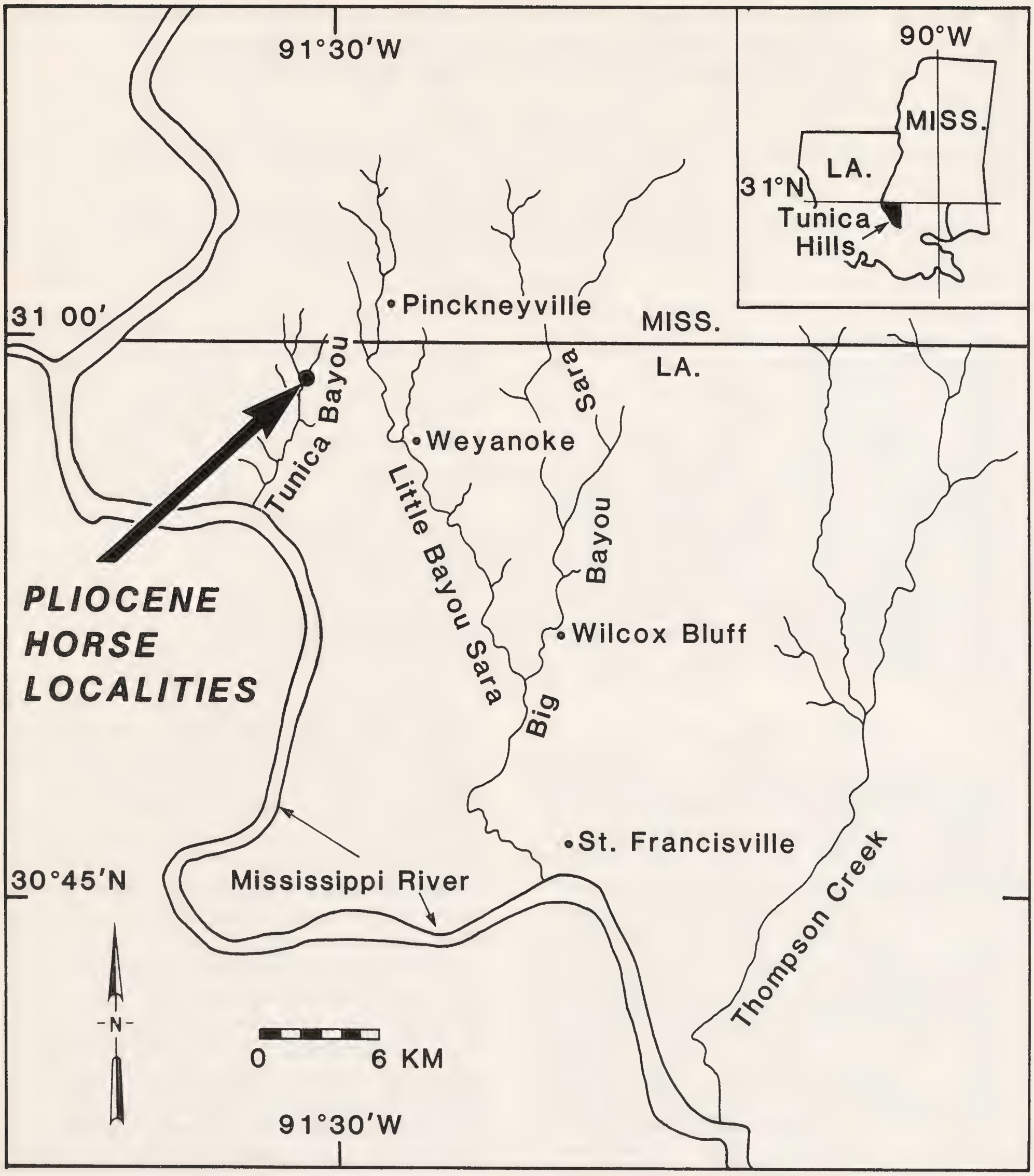

Figure 1. Location of the Pliocene horse sites and the Tunica Hills, West Feliciana Parish, Louisiana and Wilkinson County, Mississippi. Modified from Givens and Givens (1987, fig. 1) and Alford *et al.* (1983, fig. 1).

III. ACKNOWLEDGMENTS

The authors are especially grateful to Dr. A. Bradley McPherson of Shreveport and Mr. Bill Lee of Baton Rouge for permission to describe these specimens. Without their persistant collecting efforts in the Tunica Hills, the material would never have come to light. Dr. Richard C. Hulbert, Jr. (University of Florida, Gainesville) kindly allowed us the use of a then unpublished manuscript on Coastal Plain horses that was critical to the present study and also provided useful discussion of our

identifications. Dr. Frank Whitmore (U.S. Geological Survey, Washington, D.C.) graciously permitted one of us (EMM) to examine the fascinating Mauvilla fauna of Alabama. Dr. Richard Kesel (LSU Department of Geography and Anthropology, Baton Rouge) examined the sites where the specimens were found, and provided useful information on the stratigraphy of the area. Dr. Whitney J. Autin (Louisiana Geological Survey, Baton Rouge) reviewed the manuscript, and provided many helpful comments. The manuscript was also reviewed by Dr. Judith A. Schiebout (LSU Museum of Geoscience, Baton Rouge). This is University of Florida Contribution to Paleobiology number 321.

IV. ABBREVIATIONS

Fossil collections referred to in the text are: CCVC - Centenary College Vertebrate Collection, Biology Department, Centenary College, Shreveport LA; UF - Vertebrate Paleontology Collection, Florida State Museum, University of Florida, Gainesville, Florida.

V. SYSTEMATIC PALEONTOLOGY

Class MAMMALIA Linnaeus, 1758
Order PERISSODACTYLA Owen, 1848
Family EQUIDAE Gray, 1821
Subfamily EQUINAE Gray, 1821
Genus CORMOHIPPARION
Skinner & MacFadden, 1977

CORMOHIPPARION EMSLIEI Hulbert, 1987
Figures 2 c-f, 3, Table 1

Distribution: Early Pliocene (latest Hemphillian land-mammal age) of the upper Bone Valley Formation, Polk Co., central peninsular Florida; late Pliocene (late Blancan land mammal age), of the Pinecrest beds, Macasphalt Shell Pit, 3 km N of Fruitville (type locality), Sarasota Co., west-central peninsular Florida; and the Tunica Hills area, West Feliciana Parish, east-central Louisiana.

Referred Louisiana specimens: CCVC 1628, right P^3 or P^4; CCVC 1627, right P_2; CCVC 86 and CCVC 535, distal ends of MC III. (Casts of the first three specimens are deposited in the UF and LSU Museum of Geoscience collections.)

Site location: South border of sect. 62 and northern half of sect. 78 (irregular sections), T1S, R4W, Tunica 7 1/2 min. Quad., Tunica Bayou, Tunica Hills area, NW part of West Feliciana Parish, east-central Louisiana (Fig. 1). From surface stream gravel, probably derived from the Citronelle Formation (see discussion below).

Age. Early Pliocene (latest Hemphillian).

Discussion: The dental pattern in the Louisiana specimens exhibits the diagnostic characters listed in Hulbert (1987). The parastyle and mesostyles are grooved on the anterior side. The fossette borders are richly plicated with a count of 4-5 + 4-1. The pli caballin consists of a large fold with five secondary folds. The hypoconal groove is moderately deep. The protocone is elongate with a concave lingual side. The tooth is in middle wear and seems moderately hypsodont (Table 1).

The lower tooth, a right P_2, exhibits a diagnostic anterior extension of the metaconid that connects to the posterior portion of the paraconid. The protoconid and hypoconid are flattened and there is a prominent pli caballinid. Although the size of the Louisiana sample is smaller than the type from the Blancan, it falls within the size range published by Hulbert (1987) for the large sample from the late Hemphillian upper Bone Valley Formation.

There are two distal metacarpals, CCVP 86 (Fig. 3) and 535, from the Tunica Hills that seem to be referable to *Cormohipparion emsliei* based on the primitive (hipparionine) aspect of the distal tuberosities (26.9 and 28.9 mm) being greater than the width of the distal articular keel (26.4 and 27.3 mm; see Hussain, 1975) and similar proportions to that of probable *C. emsliei* metapodials from the Bone Valley.

Because North American horse species are generally widespread in geographic distribution, the occurrence of *C. emsliei* in only Florida and Louisiana suggests that it is an unusual, regional endemic species of the late Cenozoic Gulf Coastal savanna.

Genus NANNIPPUS Matthew, 1926
NANNIPPUS MINOR (Sellards, 1916)
Figures 2 a-b, Table 1

Distribution: Early Pliocene (late Hemphillian) of Central and southern North America.

Referred Louisiana specimen: CCVC 585, left M^2.

Site, age and stratum: See description above for *Cormohipparion emsliei.*

Discussion: The tooth (Fig. 2, Table 1) is too small to be allocated to *Cormohipparion*

TABLE 1
Measurements (in mm) of the teeth of Pliocene three-toed horses from the Tunica Hills.

Specimen No.	Element	Greatest antero-posterior length (excluding cement)	Greatest transverse width (excluding cement)	Height (upper-mesostyle; lower-paraconid)
		Cormohipparion emsliei		
CCVC 1628	RP^3 or P^4	18.8	17.0	37.5
CCVC 1627	RP_2	20.6	9.0	30.4
		Nannippus minor		
CCVC 585	LM^2	16.5	15.0	35.7

emsliei. Although broken on the occlusal surface, the parastyle and metastyle seem unconstricted. The fossettes are moderately plicated (3-3-4-2). There is a well developed pli caballin. The protocone is elongate with a concave lingual border. This tooth, which is in middle wear stage, seems too low-crowned to be referable to *Nannippus peninsulatus* (senior synonym of *N. phlegon*). It falls within the large end of the observed range and has a dental pattern consistent with that of *Nannippus minor* (MacFadden, 1984; Hulbert, 1987).

VI. AGE OF THE TUNICA HILLS HIPPARIONINES

The presence of the two hipparionines *Cormohipparion emsliei* and *Nannippus minor* suggests a latest Hemphillian, or early Pliocene, age for the sub-Pleistocene stratum of the Tunica Hills. This is based on: 1) the age of the upper Bone Valley Formation of Florida, the only other place where these two taxa are known to co-occur; and 2) the primitive stage of evolution of *C. emsliei* from Louisiana, which is of similar size to the Bone Valley occurences of this species (and smaller than the Blancan specimens). The biochronology of the upper Bone Valley fauna is well established (*e.g.*, MacFadden, 1986) and probably represents a time interval between 5.4-4.5 myr ago, or early Pliocene, using the time-scale of Berggren *et al.* (1985).

VII. STRATIGRAPHIC PROVENIENCE

The Tunica Hills have long been known for their rich fossil flora (see review in Givens and Givens, 1987), freshwater mollucks (Richards, 1938) and vertebrates (see reviews in Domning, 1969 and Lowery, 1974). Recent work has shown that nearly all of the vertebrates have derived from low level (T1) terrace deposits of late Pleistocene age (Givens and Givens, 1987). No older vertebrates have previously been reported from the area.

The fossil horse material described here was found loose in the surface stream gravel along Tunica Bayou (Fig. 1), as are most vertebrate fossils from the Tunica Hills. *In situ* recovery of vertebrates is uncommon and the discovery of even partially articulated material (such as the partial mastodon skeleton figured in Lowery 1974, p. 519) is extremely rare. Even when found in place, most vertebrate material consists of isolated, often badly stream worn, elements in channel gravel or sand.

The outcrops exposed in the area of Tunica Bayou where the horse material was found consist of reworked loess, sand and thin gravel stringers typical of much of the Tunica Hills Pleistocene. One of the Pliocene horses, CCVC 1628, was even found in the same area as Rancholabrean (late Pleistocene) mammals reported by Domning (Arata and Domning MS, *in* Domning, 1969, p. 393). The Rancholabrean fauna found in the stream beds of the Tunica Hills probably derives from the slumping of this material into the bayous, with the gravel-sized fraction concentrated later at the stream surface. The composition of the loess in the area, containing stringers of sand and fine gravel, suggests that it is reworked colluvium, and is not *in situ* (Fisk, 1938; Delcourt and Delcourt, 1977; Alford, Kolb and Holmes, 1983). If this is the case, then the Pleistocene vertebrate fauna may have been reworked

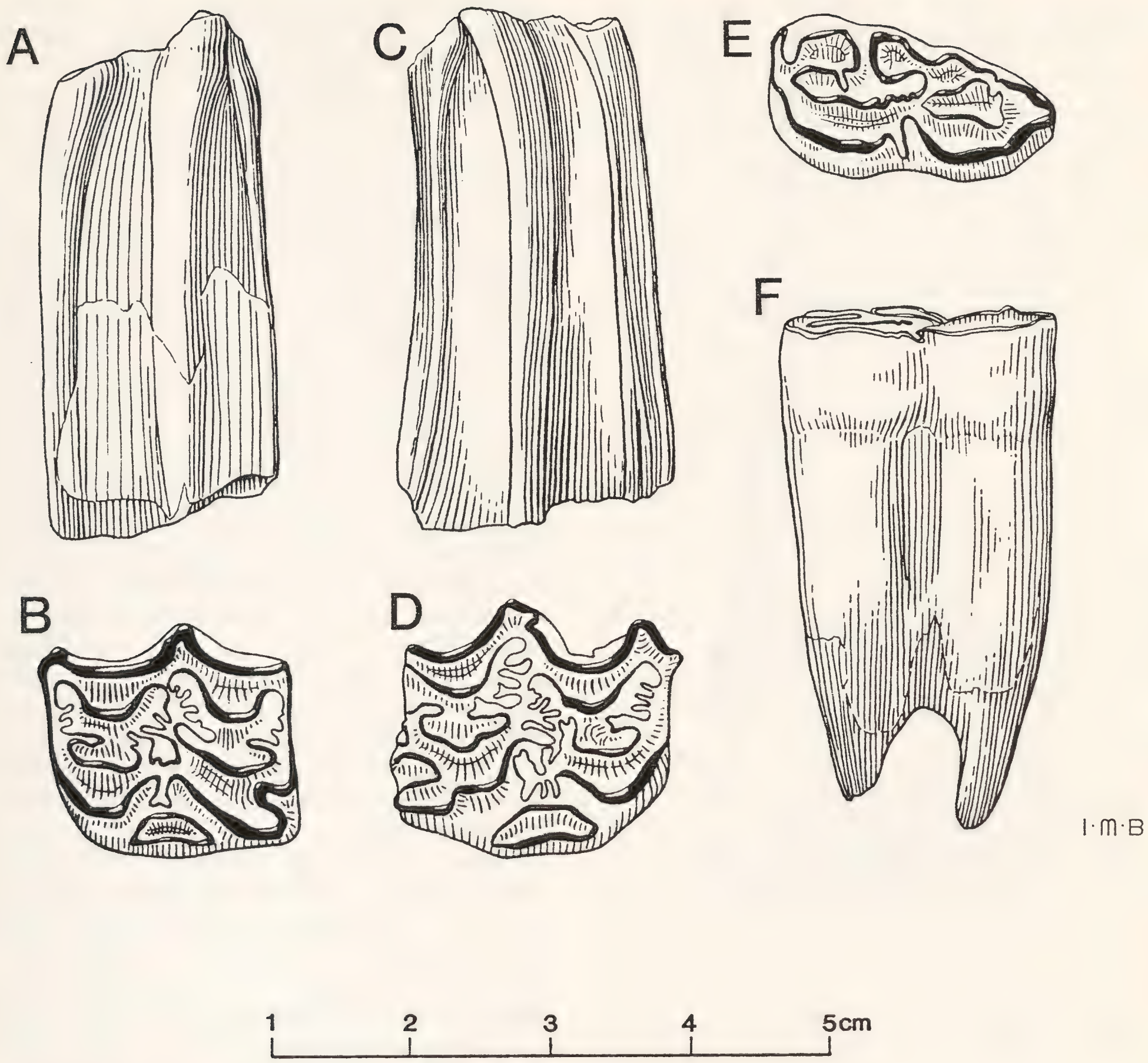

Figure 2. *Cormohipparion emsliei* (C-F) and *Nannippus minor* (A-B) from the early Pliocene of the Tunica Hills, West Feliciana Par., La. A-B: CCVC 585, left M^2, lateral and occlusal views. C-D: CCVC 1628, right P^3 or P^4, lateral and occlusal views. E-F: CCVC 1627, right P_2, in occlusal and lateral views.

twice. Specimen wear (including nearly rounded cobbles of mastodon bone) tends to corroborate this hypothesis.

Because the hipparionine horses described here are of Pliocene age (based on distribution of the species elsewhere, particularly Florida), they must have originally derived from a bed *below* that in which the much larger Rancholabrean fauna was buried. Because of the relatively unworn state of the fossils described here (despite evident reworking), it is unlikely that they were derived from a very distant source. The underlying Pascagoula Formation is known to be of late Miocene age (see sect. X) and, therefore, it is most likely that the Pliocene horses were derived from the Citronelle Formation, which is the bed usually underlying the Pleistocene beds in the Tunica Hills.

It is worth noting that while Rancholabrean fossils have been found in nearly every major drainage of West Feliciana Parish (Tunica Bayou, Kimball Creek, Little Bayou Sara, Bayou Sara, Thompson's Creek, etc.), Pliocene vertebrates are only known from a small area on Tunica Bayou. This possibly suggests a limited, local source bed.

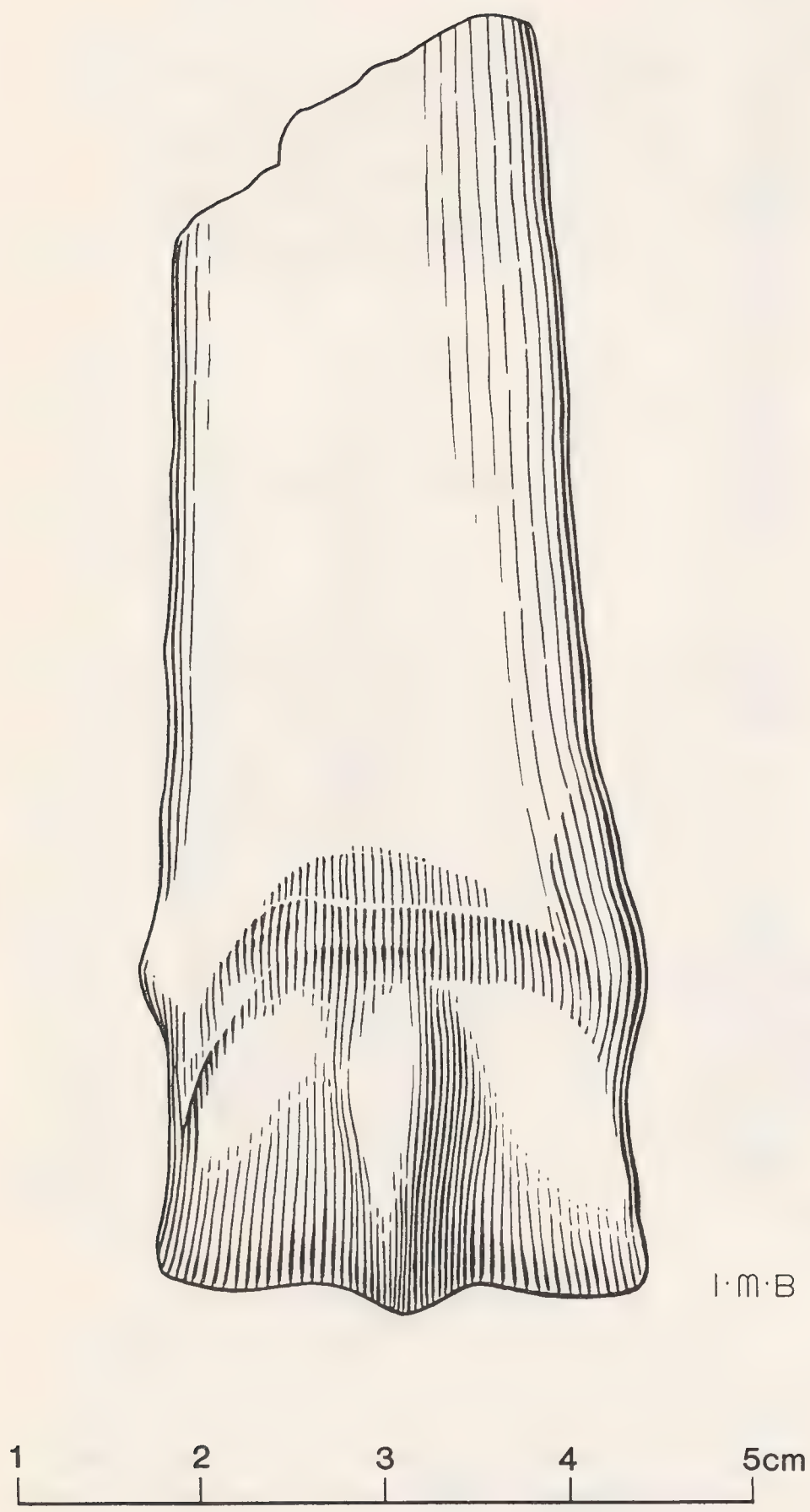

Figure 3. *Cormohipparion emsliei* from the early Pliocene of the Tunica Hills. CCVC 86, dorsal view of distal metacarpal III.

VIII. PLIOCENE TERRESTRIAL VERTEBRATES OF THE GULF AND ATLANTIC COASTAL PLAIN

Unlike Miocene terrestrial vertebrates, which have an extensive, if spotty, record from the southeastern North American Coastal Plain (see review in Tedford and Hunter, 1984), non-marine Pliocene vertebrates are well represented only in Florida and North Carolina. Considering the extensive surface exposures of Pliocene sediments in the area, it is surprising that Pliocene terrestrial faunas are not better known. The better known coastal Pliocene faunas are both earliest Pliocene (latest Hemphillian land mammal age), whereas later Pliocene (Blancan land mammal age) Coastal Plain faunas are unknown outside Florida. The following brief review of Pliocene terrestrial vertebrates from the Coastal Plain discusses the principal localities of this age.

Texas - Although late Hemphillian and Blancan faunas are well known from the High Plains Ogallala Group of the north Texas panhandle (see review in Schultz, 1977), and Blancan fossils are recorded from the Basin and Range bolsons of western Texas (Akersten, 1972), Pliocene terrestrial vertebrates have not been recorded from the Texas coastal plain. This is surprising in light of the extensive record of Miocene terrestrial vertebrates of the Texas coastal plain (Quinn, 1955; Wilson, 1956; Patton, 1969; Patton and Taylor, 1971; Forsten, 1975; Prothero and Manning, 1987, etc.). The Goliad Formation has, at times, been identified as Pliocene, but vertebrate faunas of the Goliad are of middle to late Miocene (late Barstovian/early Clarendonian) age (Prothero and Manning, 1987).

Louisiana and Mississippi - Until the present report, no Pliocene terrestrial fossils had been reported from either state (see review in Domning, 1969). The Miocene terrestrial vertebrate record from these states is little better, limited as yet to a single pair of gomphothere tusks from the middle Miocene part of the Fleming Formation of western Louisiana (Arata, 1966).

Alabama - "Middle Pliocene" terrestrial vertebrates have been reported from southwest Alabama (Isphording and Lamb, 1971; Thurmond and Jones, 1981); but this age assignment was based on an outdated correlation of the Hemphillian. Except for the latest faunas, the Hemphillian is now generally considered to be of late Miocene age (Tedford, *et al.*, 1987). This Mauvilla, or Mobile, Local Fauna (see Whitmore *in* Isphording and Lamb, 1971, p. 776 and Isphording and Flowers, 1983 pp. 71-72; Tedford and Hunter, 1984, p. 144) can be dated as early (or middle) Hemphillian, rather than late, on the basis of the presence of *Synthetoceras* cf. *tricoronatus* in assocation with advanced rhinocerotid taxa. A middle Hemphillian

age has been indicated by Tedford and Hunter (1984 p. 144). With the Mauvilla Local Fauna reassigned to the late Miocene, Alabama also has no Pliocene terrestrial vertebrates.

Florida - Unlike Gulf Coastal states to the west, Florida has an extensive Pliocene terrestrial vertebrate record. An excellent late Hemphillian fauna has long been known from the fluvio-deltaic upper part of the Bone Valley Formation, extensively exposed in the phosphate mines of central peninsular Florida (see review in MacFadden and Webb, 1982). Several Blancan faunas, *e.g.*, the Haile XVA site (Robertson, 1976) and Santa Fe River localities have been reported from peninsular Florida (see MacFadden and Waldrop, 1980). Unlike the Gulf Coastal states to the west, Florida also has an extensive early Pliocene marine fossil record, in the upper Choctawhatchee Group. The difference relative to Louisiana, for example, is due to the distance of Florida away from the clastic-dominated delta facies of the Mississippi River.

Despite extensive surface exposures of Pliocene sediments on the Atlantic Coastal Plain (Cronin, *et al.*, 1984), Pliocene terrestrial vertebrates in this area are also generally poorly represented.

Georgia - Voorhies (1974) reported the occurrence of a possible early Pliocene (latest Hemphillian) *Nannippus minor* from upland gravel beds in central Georgia.

North Carolina - A relatively large early Pliocene (latest Hemphillian) terrestrial vertebrate fauna is known from the Yorktown Formation at Lee Creek Mine, near Aurora. The fauna has been listed (R. Eschelman *in* Tedford and Hunter, 1984, pp. 138-139), but has not yet been fully described.

In summary, the horses described here are the only Pliocene terrestrial vertebrates presently known from the Gulf Coastal Plain west of peninsular Florida.

IX. COMMENTS ON THE CITRONELLE FORMATION

Extent - As originally studied by Matson (1916), the Citronelle included reddish and orange sands and gravels in a belt along the northcentral Gulf Coast from western Louisiana to the western Florida panhandle. Matson named the beds for outcrops near the city of Citronelle, in southwest Alabama. The outcrop area has now expanded across the Gulf and Atlantic Coastal Plain. Doehring (1958, p 773) included "a belt of up to 100 miles wide which extends for 1,500 miles from the Nueces River in south Texas to the vicinity of Washington, D.C."

Sediment - Citronelle clastics vary, but they are dominated in outcrop by quartz sand and chert gravel (Matson, 1916, p. 174). The sand and gravel is gray-white when fresh (Rosen, 1968), but weathers to pink, red, or orange as its iron cement oxidizes to ferric hydroxide (Parsons, 1967). Generally, these clastics are only slightly consolidated. Sedimentary structures such as channels, cut and fill, scour surfaces, and cross-bedding are locally common in the Citronelle (Autin, *et al.*, 1986, p. 420). Interbedded with the coarse clastics are minor beds of silts and clays (Parsons, 1967, pp. 41 and 44).

Paleoecology - Early work on these beds suggested that they might be glacial "drift" (Hopkins, 1872; Lerch, 1892) or marine (McGee,1891; Harris and Veatch, 1899), but most workers in this century have agreed that the Citronelle is predominately of fluviatile origin. It has been described as "...an alluvial plain built up by braiding, coalescing streams crossing a gently sloping coastal plain." (Parsons, 1967, p 49). This interpretation has been supported by more recent work (Smith and Meylan, 1983, p. 430). The presence of two Pliocene horses with very high-crowned (grazing type) teeth in the Tunica Hills suggests that at least the upland part of the Citronelle must have had nearby grasslands during deposition. There are considerable changes in the Citronelle from north to south. Clastics are generally coarser to the north and finer to the south, and the southern deposits are party estuarine (Matson, 1916, p. 187). Matson noted that the varying sediment types suggested that the source streams varied considerably in both direction and velocity (1916, p. 187). Some beds suggest flood deposits while others suggest quiet pond deposition.

Source - Derivation from northern glacial outwash (*e.g.*, Fisk, 1939), or an area west of the Mississippi (Clendenin, 1896, p.196),

or an ancestral Mississippi drainage (Russell, 1987), have all been suggested but mineralogical analysis points strongly to a southern Appalachian source area, at least for Citronelle deposits in Mississippi and Alabama (Rosen, 1968 and 1969; Isphording, 1976; Isphording, 1983; Isphording and Flowers, 1983; Smith and Meylan, 1983). The later work tends to support an earlier hypothesis of a southern Appalachian source area (Brown, 1967). The Citronelle heavy mineral suite differs from both that of late Pleistocene glacial terrace sediment and that of modern Mississippi River sediment (Rosen, 1968 and 1969). Middle Paleozoic invertebrates found in chert pebbles from central Gulf Coast Citronelle gravels (and reworked into Pleistocene gravels) may also derive from the southern Appalachians (Rosen, 1968, p. 10; Smith and Meylan, 1983, p. 424).

Relationship to the Coastal Plain Sequence - As emphasized by Doehring (1958), unlike the underlying Coastal Plain beds, the basal Citronelle is often strikingly unconformable. While most Coastal Plain sediments rest only on the next older bed, the Citronelle often overlies much older units. On the eastern flank of the Sabine Uplift in northwest Louisiana, the Citronelle overlies Eocene beds. This distinctive unconformity, in addition to it nonmarine origin, suggests that the Citronelle is not part of the typical Coastal Plain sequence. Contrary to Doehring (1958), this does not mean that the Citronelle is part of a Pleistocene sequence.

Relationship to Pleistocene Beds - There has been tremendous confusion about the relationship of the Citronelle to overlying Pleistocene beds. This is mostly due to the fact that many of the Pleistocene beds incorporated large amounts of Citronelle sand and gravel during deposition (Isphording and Lamb, 1971, p. 775). As a result, they often look very similar and contain similar lithologies. This makes contacts difficult to discern and resulting maps and thickness estimates of the Citronelle suspect. Doehring (1958, p. 778) states that some Citronelle outcrops have been mapped as Williana Terrace, and Rosen (1968) noted that parts of Matson's mapped Citronelle outcrop was included by Fisk (1939) as Williana, Bentley, and even Montgomery terrace deposits. That the Citronelle was not contemporaneous with the Williana has been indicated by Russ (1976, p. 1081), who noted that the Williana surfaces cut into the Citronelle in the Red River area of Louisiana.

Fossils - Despite its enormous surface exposure, the Citronelle has produced very few fossils. There are probably several reasons for the scarcity of fossils. High energy gravels often destroy any contained fossils. Shallow braided streams generally preserve fewer vertebrates than do deeper channels. Leaching during the weathering process may have dissolved some fossils, though Matson noted that even some unweathered beds he examined were non-fossiliferous (1916, p. 186). The major exception is the plant material described by Berry (1916) from unweathered clays in southwest Alabama. He described well-preserved leaves, seeds, and nuts of at least 18 species, revealing a coastal flora similar to that of coastal Alabama today, with abundant bald cypress and live oak. He suggested that the plants lived near a quiet, coastal lagoon, which was protected by a barrier beach. Although it has been argued that the plants are from a bed below the Citronelle (Roy, 1939; Carlston, 1950), more recent work (Stringfield and LaMoreaux, 1957, p. 746; Isphording and Flowers, 1983, p. 68) has corroborated the view that the plants occur in the Citronelle. No *in situ* vertebrate material is known from the Citronelle Formation.

X. AGE OF THE CITRONELLE

Flora - Matson (1916) based his Pliocene age assignment on the floral determinations made by Berry (1916, published at the same time as Matson's paper) as well as the fact that the Citronelle is overlain by Pleistocene sediment. Berry suggested a late Pliocene age (1916, p. 195) because some Citronelle plants are not present in the Pleistocene. It must be added that, at the time, no Pliocene floras from North America were available for comparison.

Doehring (1958) suggested that the plants might be of early Pleistocene, rather than Pliocene, age. This argument appears to have been part of an effort to place the Citronelle in the same depositional system as the overlying Pleistocene

deposits. Doehring considered the Citronelle a pre-glacial Pleistocene deposit. Doehring's age assignment of Berry's flora has been contested by Stringfield and LaMoreaux, who included a confirmation of Berry's Pliocene date by R. W. Brown of the USGS (1957, p. 746). On the other hand, a study of pollen from the middle and upper Citronelle Formation from western-most Florida by Estella Leopold indicated a Quaternary age (Marsh, 1964, p. 83).

Underlying Beds - A maximum age for the Citronelle can be obtained from the age of the youngest underlying beds. As noted by Matson (1916, p. 172), the Citronelle lies unconformably upon the Pascagoula Formation in Mississippi. A small invertebrate fauna from the Pascagoula in southeastern Mississippi was reported by Mincher (1941), who compared its age to that of the *Arca* zone in Florida, now thought to be of late Miocene (planktonic foraminiferal zone N17) age (Akers, 1972, p. 14). In southwest Alabama, the Citonelle overlies a sand and clay bed (possibly the Ecor Rouge Member of the Catahoula Formation), which contains the previously mentioned Mauvilla Local Fauna (Isphording and Flowers, 1983, pp. 69-71) of late Miocene age. Thus, in at least two places, the Citronelle overlies late Miocene (late Hemphillian and probably Messinian European stage) sediments.

Overlying Beds - A minimum age for the Citronelle can be obtained from the age of the overlying beds. Several authors have noted Pleistocene beds overlying the Citronelle (Matson, 1916; Mayer, 1932, p. 34; Parsons, 1967; Rosen, 1968; Isphording and Lamb, 1971, p. 775; Russ, 1976; Isphording and Flowers, 1983; etc.). Stringfield and LaMoreaux (1957, p. 746) note that the Citronelle is overlain by the oldest Pleistocene marine terrace in Florida.

Correlation - The above data argue strongly for a Pliocene age for at least part of the Citronelle, as originally proposed by Matson (1916). It has been suggested (Tedford and Hunter, 1984, Fig. 4.) that the Citronelle may be a lateral equivalent of several early Pliocene transgressive beds in Florida, *i.e.*, the Jackson Bluff Formation of the panhandle, the uppermost Bone Valley Formation of the central peninsula, and the Tamiami Formation of the south. The similarity of horse taxa described here with those of the Bone Valley corroborate these correlations.

XI. THE CITRONELLE FORMATION IN THE TUNICA HILLS

As elsewhere in the Gulf Coast, the Citronelle Formation has often been confused with both older and younger beds in Louisiana. As a result, much basic geologic data on the unit (outcrop distribution, thickness, and even stratigraphic terminology) in the state is equivocal.

Hilgard (1860) included Citronelle beds in the Tunica Hills of Louisiana and Mississippi as part of a Quaternary unit that he identified as "Orange Sand." In a later work (1869), he grouped Citronelle material with Eocene sediment under the same name. Hopkins (1872) included Citronelle material as part of a "Northern Drift." McGee (1891) included Citronelle beds in his Lafayette Formation, a unit he considered to be a pre-Pleistocene marine bed. Lerch (1892) included Citronelle sediment in beds he identified as "Drift." Harris and Veatch (1899) included Citronelle beds with Eocene sediment in their usage of McGee's "Lafayette." They considered the Lafayette to be a late Pliocene coastal deposit. Matson (1916), in the original description of the Citronelle, described the bed in the Tunica Hills area as "Yellow and red sands and clays, locally gray where unweathered. Much gravel near the landward margin and in valleys of principle streams."

Parsons (1967) noted that the Citronelle overlies silts and clays in Louisiana, but did not identify these beds. Brown and Guyton (1943) identified these underlying beds as Pascagoula Formation. Parsons noted (1967, pp. 37-38) that the basal Citronelle contact in the Tunica Hills area could be either a sharp unconformity or a transitional zone.

Rosen (1968, 1969) studied the mineralogy of the Tunica Hills Citronelle in detail, and noted that it is the principal aquifer of the Baton Rouge area.

Because many Pleistocene beds (particularly the gravels) in the Tunica Hills are derived from reworked Citronelle, it is dif-

ficult to draw a boundary between the two. Many people have included nearly all of West Feliciana Parish in the Citronelle outcrop area (Matson, 1916; Parsons, 1967; Rosen, 1968). The presence of late Pleistocene (Rancholabrean) vertebrates in bayous across the parish (as well as the presence of extensive loess outcrop) shows this to be incorrect. While Citronelle may underlie much of the parish, most of the surface exposure is clearly of late Pleistocene age or younger. Recent geologic work, such as the geologic map of the state by the Louisiana Geological Survey (Snead and McCulloh, 1984), unites the Citronelle with the Williana and highest Bentley terraces simply as "High Terraces," avoiding the boundary problem entirely. It is worth noting that, as yet, no early Pleistocene (Irvingtonian land mammal age) vertebrates have been recovered from the Tunica Hills. An early Pliocene/late Pleistocene unconformity may exist in much of the area. The present description provides strong evidence for a nearly Pliocene age for the Citronelle Formation in east-central Louisiana, based on the presence of biochronologically diagnostic late Hemphillian horses.

XII. LITERATURE CITED

AKERS, W. H., 1972, Planktonic foraminifera and biostratigraphy of some Neogene formations, northern Florida and Atlantic Coastal Plain. Tulane Stud. Geol. Paleont. 9(1-4): 139 p.

AKERSTEN, W. A., 1972, Red Light Local Fauna (Blancan) of the Love Formation, southeastern Hudspeth County, Texas. Texas Mem. Mus., Bull. 20: 52 p.

ALFORD, J. J., C. R. KOLB, and J. C. HOLMES, 1983, Terrace stratigraphy in the Tunica Hills of Louisiana. Quat. Res. 19:55-63.

ARATA, A. A., 1966, A Tertiary proboscidean from Louisiana. Tulane Stud. Geol. 4(2): 73-74.

AUTIN, W. J., J. J. ALFORD, B. J. MILLER, and R. P. SELF, 1986, The Florida parishes of southeastern Louisiana. Geol. Soc. Amer. Cent. Field Guide, Southeastern Sect., 1986:419-424.

BERGGREN, W. A., D. V. KENT, J. J. FLYNN, and J. A. VAN COUVERING, 1985, Cenozoic geochronology. Bull. Geol. Soc. Amer. 96:1407-1418.

BERRY, E. W., 1916, The flora of the Citronelle Formation. U.S. Geol. Surv. Prof. Paper 98-L: 193-208, pls. 45-47.

BROWN, B. W., 1967, A Pliocene Tennessee River hypothesis for Mississippi. Southeastern Geol. 8:81-84.

BROWN, G. F., and W. F. GUYTON, 1943, Geology and ground water supply at Camp Van Dorn. Bull. Mississippi Geol. Surv. 56: 68 p.

CARLSTON, C. W., 1950, Pleistocene history of coastal Alabama. Bull. Geol. Soc. Amer. 61: 1119-1130.

CLENDENIN, W. W., 1896, A preliminary report upon the Florida parishes of east Louisiana. p. 187-192. *In* Geology and Agriculture of Louisiana pt. 3, Rept. Louisiana St. Expt. Sta., p. 159-256.

CRONIN, T. M., L. M. BYBELL, R. Z. POORE, B. W. BLACKWELDER, J. C. LIDDICOAT, and J. E. HAZEL, 1984, Age and correlation of emerged Pliocene and Pleistocene deposits, U.S. Atlantic Coastal Plain, Palaeogeog., Palaeoclimatol, Palaeoecol. 47(1/2): 21-51.

DELCOURT, P. A., and H. R. DELCOURT, 1977, The Tunica Hills, Louisiana - Mississippi: late glacial locality for spruce and deciduous forest species. Quat. Res. 7: 218-237.

DOEHRING, J.A., 1958, Citronelle age problem. Bull. Amer. Assoc. Petrol. Geol. 42(4): 764-786.

DOMNING, D. P., 1969, A list, bibliography, and index of the fossil vertebrates of Louisiana and Mississippi. Trans. Gulf Coast Assoc. Geol. Socs. 19: 385-422.

FISK, H. N., 1938, Pleistocene exposures in western Florida parishes of Louisiana. Bull. Louisiana Geol. Surv. 12: 3-25.

FISK, H. N., 1939, Depositional terrace slopes in Louisiana. Jour. Geomorphology 2(2): 181-200.

FORSTEN A., 1975, The fossil horses from the Texas Gulf Coastal Plain. Jour. Paleontology 49(2): 395-399.

GIVENS, C. R., and F. M. GIVENS, 1987, Age and significance of fossil white spruce (*Picea glauca*), Tunica Hills, Louisiana - Mississippi. Quat. Res. 27: 283-296.

HARRIS, G. D., and A. C. VEATCH, 1899, A preliminary report on the geology of Louisiana. Louisiana St. Expt. Sta., Rept. Geol. Agr., pt. 5, 139 p.

HILGARD, E. W., 1860, Report on the geology and agriculture of the state of Mississippi. E. Barksdale, Jackson, xxiv and 391 p.

HILGARD, E. W., 1869, Preliminary report of a geological reconnaissance of Louisiana. DeBow's New Orleans Mon. Rev., p. 11.

HOPKINS, F. V., 1872, Third annual report of the Geological Survey of Louisiana. Louisiana St. Univ., Ann. Rept. of 1871, p. 163-206.

HULBERT, R. C., Jr., 1987, A new *Cormohipparion* (Mammalia, Equidae) from the Pliocene (latest Hemphillian and Blancan) of Florida. Jour. Vert. Paleontology 7(4): 451-468.

HUSSAIN, S. T., 1975, Evolutionary and functional anatomy of the pelvic limb in fossil and recent Equidae (Perissodactyla, Mammalia). Anat., Histol., Embryol. 4: 179-222.

ISPHORDING, W. C., 1976, Multivariate mineral analysis of Miocene - Pliocene Coastal Plain sediments. Trans. Gulf Coast Assoc. Geol. Socs. 26: 326-331.

ISPHORDING, W. C., 1983, Interpretive mineralogy: examples from Miocene Coastal Plain sediments. Trans. Gulf Coast Assoc. Geol. Socs. 33: 295-305.

ISPHORDING, W. C., and G. C. FLOWERS, 1983, Differentiation of unfossiliferous clastic sediments: solutions from the southern portion of the Alabama - Mississippi Coastal Plain. Tulane Stud. Geol. Paleont. 17(3): 59-83.

ISPHORDING, W. C., and G. M. LAMB, 1971, Age and origin of the Citronelle Formation in Alabama. Bull. Geol. Soc. Amer. 82(3): 775-779.

LERCH, O., 1892, A preliminary report upon the hills of north Louisiana north of the U.S. and P. Railroad. Bull. Louisiana St. Expt. Stat., Rept. Geol. Agr. pt. 1, 51 p.

LOWERY, G. H., 1974, The mammals of Louisiana and its adjacent waters. LSU press, Baton Rouge, 565 p.

MacFADDEN, B. J., 1984, Systematics and phylogeny of *Hipparion, Neohipparion, Nannippus* and *Cormohipparion* (Mammalia, Equidae) from the Miocene and Pliocene of the New World. Bull. Amer. Mus. Nat. Hist. 179, art. 1: 195 p.

MacFADDEN, B. J., 1986, Late Hemphillian monodactyl horses (Mammalia, Equidae) from the Bone Valley Formation of Central Florida. Jour. Paleontology 60: 466-475.

MacFADDEN, B. J., and J. S. WALDROP, 1980, *Nannippus phlegon* (Mammalia, Equidae) from the Pliocene (Blancan) of Florida. Bull. Florida State Mus., Biol. Sci. 25: 1-37.

MacFADDEN, B. J., and S. D. WEBB, 1982, The succession of Miocene (Arikareean through Hemphillian) terrestrial mammalian localities and faunas in Florida. *In* T. M. SCOTT and S. B. UPCHURCH, Miocene of the southeastern United States. Florida Bur. Geol., Spec. Publ. 25: 186-199.

MARSH, O. T., 1964, Geology of Escambia and Santa Rosa counties, western Florida panhandle. Florida Geol. Surv., Bull. 46: 140 p.

MATSON, G. E., 1916, The Pliocene Citronelle Formation of the Gulf Coastal Plain. U. S. Geol. Surv., Prof. Paper 98-L: 167-192, pls. 33-42.

MAYER, M. J., 1932, A contribution to the geology of Bienville Parish, Louisiana. Unpubl. MS thesis, Louisiana State Univ., Baton Rouge, 62 p.

McGEE, W. J., 1981, The Lafayette Formation. 12th Ann. Rept., U.S. Geol. Surv., pt. 1, p. 347-521.

MINCHER, A. R., 1941, The fauna of the Pascagoula Formation. Jour. Paleontology 15(4): 337-348, pls. 46-47.

PARSONS, B. E., 1967, Geologic factors influencing recharge to the Baton Rouge ground-water system, with emphasis on the Citronelle Formation. Unpubl. MS thesis, Louisiana State Univ., Baton Rouge, vii and 74 p.

PATTON, T. H., 1969, Miocene and Pliocene artiodactyls, Texas Gulf Coastal Plain. Bull. Florida St. Mus., Biol. Sci. 14: 115-226.

PATTON, T. H., and B. E. TAYLOR, 1971, The Synthetoceratinae (Mammalia, Tylopoda, Protoceratidae). Bull. Amer. Mus. Nat. Hist. 145: 119-218.

PROTHERO, D. R., and E. M. MANNING, 1987, Miocene rhinoceroses from the Texas Gulf Coastal Plain. Jour. Paleontology 61(2): 388-423.

QUINN, J. H., 1955, Miocene Equidae of the Texas Gulf Coastal Plain. Publ. Univ. Texas (5516): 102 p., 14 pls.

RICHARDS, H. G., 1938, Some Pleistocene freshwater mollusks from Louisiana and Mississippi. Bull. Louisiana Geol. Surv. 12:27-46, 105-113.

ROBERTSON, J. S., 1976, Latest Pliocene mammals from Haile XV A, Alachua Co., Florida. Bull. Florida. St. Mus. 20(3): 111-186.

ROSEN, N. C., 1968, Heavy minerals of the Citronelle Formation of the Gulf Coastal Plain. Unpubl. Ph.D. dissert., Louisiana State Univ., Baton Rouge, vii and 187 p.

ROSEN, N. C., 1969, Heavy minerals and size analysis of the Citronelle Formation of the Gulf Coastal Plain. Jour. Sed. Petrol. 39: 1552-1565.

ROY, C. J., 1939, Type locality of the Citronelle Formatin, Citronelle, Alabama. Bull. Amer. Assoc. Petrol. Geol. 23: 1553-1559.

RUSS, D. P., 1976, Reinterpretation of the Williana-Citronelle relationship [abstr.]. Geol. Soc. Amer. Abstr. Prog. 8(6): 1080-1081.

RUSSELL, E. E., 1987, Gravel aggregate in Mississippi - its origin and distribution. Mississippi Geol. 7(3): 7 p.

SCHULTZ, G. E. (ed), 1977, Guidebook. Field Conference on late Cenozoic biostratigraphy of the Texas panhandle and adjacent Oklahoma. Special Publ. Killgore Res. Center, Dept. of Geol. and Anthro. (1): vii and 160 p.

SMITH, M. L., and M. MEYLAN, 1983, Red Bluff, Marion County, Mississippi: a Citronelle braided stream deposit. Trans. Gulf Coast Assoc. Geol. Socs. 33: 419-432.

SNEAD, J. I., and R. P. McCULLOH, comps., 1984, Geologic map of Louisiana, 1984. Louisiana Geol. Surv. Baton Rouge, 1: 500,000.

STRINGFIELD, V. T., and P. E. LaMOREAUX, 1957, Age of Citronelle Formation in Gulf Coastal Plain. Bull. Amer. Assoc. Petrol. Geol. 41(4): 742-746.

TEDFORD, R. H., T. GALUSHA, M. F. SKINNER, B. E. TAYLOR, R. W. FIELDS, J. R. MACDONALD, T. H. PATTON, J. M. RENSBERGER, and D. P. WHISTLER, 1987, Faunal succession and biochronology of the Arikareean through Hemphillian interval (late Oligocene through earliest Pliocene epochs), in North America. Chap. 6, p. 153-210. *In* M. O. WOODBURNE (ed), Cenozoic Mammals of North America: Geochronology and Biostratigarphy. Univ. of California Press, Berkeley, xv + 336 p.

TEDFORD, R. H. and M. E. HUNTER, 1984, Miocene marine-nonmarine correlations, Atlantic and Gulf Coastal Plains, North America. Palaeogeog., Palaeoclimatol., Palaeoecol. 47(1-2): 129-151.

THURMOND, J. T., and D. E. JONES, 1981, Fossil vertebrates of Alabama. Univ. of Alabama Press, University, ix + 244 p.

VOORHIES, M. R., 1974, The Pliocene horse *Nannippus minor* in Georgia: geologic implications. Tulane Stud. Geol. Paleont. 11(2): 109-113.

WEBB, S. D., 1974, Chronology of Florida Pleistocene mammals. p. 5-31. *In* S. D. WEBB (ed), Pleistocene mammals of Florida, University Presses of Florida, Gainesville, x + 270 p.

WILSON, J. A., 1956, Miocene formations and vertebrate biostratigraphic units, Texas Coastal Plain. Bull. Amer. Assoc. Petrol. Geol. 40: 2233-2246.

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PLEISTOCENE FRESHWATER MOLLUSKS ON THE FLOOR OF OWENS LAKE PLAYA, EASTERN CALIFORNIA

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ABSTRACT

Patches of shelly sediments on the floor of Owens Lake playa contain a freshwater molluscan fauna dominated by two planorbid snails, *Helisoma newberryi* (Lea) and *Vorticifex effusa* (Lea). Other less common species include the valvatid snails, *Valvata utahensis* Call and *Valvata humeralis* Say; the planorbid, *Gyraulus parvus* (Say); and a sphaeriid clam, *Pisidium* sp. The assemblage is indicative of a fully developed pluvial lake. Other studies have demonstrated that the late Pleistocene (probably early Wisconsinan) source beds for these mollusks are folded and faulted in the vicinity of Point Bartlett, with the shells having been eroded and reworked during late Wisconsinan and Holocene lake level highstands. A trench excavated in this area confirms this complex pattern of reworking from truncated limbs of folded Pleistocene lake beds. In this way, older Pleistocene mollusks have "leaked" into younger Pleistocene and Holocene depositional environments, potentially mixing fossils from different pluvial cycles.

INTRODUCTION

The floor of Owens Lake, now an intermontane playa in the southwestern Great Basin, is dotted with small patches of shelly sediments. In the vicinity of Point Bartlett and the old Pittsburgh Plate Glass Company soda plant in the northwestern portion of the playa (Figures 1, 2), the shelly patches are roughly circular to elongate in outline and generally less than 3 m in longest dimension. On first inspection the shelly patches appear to be windrows, bars and thin blankets of littoral lake deposits containing thousands of planorbid snails, formed during the last series of Holocene highstands of lake level (see Smith and Street-Perrott, 1983). Trenching reveals, however, that some of the shelly patches are surface "leaks" where older Pleistocene mollusks have been reworked into younger Pleistocene and Holocene depositional environments. Other shelly areas in the same part of the playa are, in fact, Holocene littoral bars and sediment veneers containing shells presumably derived from the leaks. This suggests a complex pattern of exposure and redistribution of freshwater fossils, and their incorporation in much younger deposits–a potentially important process in tectonically active lacustrine basins.

In this paper I describe the mollusks from a series of samples collected "offshore" from Point Bartlett, in an area of folded and faulted Pleistocene lake beds (structures described in detail by Carver, 1969). This is the only complete inventory of Pleistocene freshwater mollusks documented for Owens Lake, although mollusks from the lake and other localities in the region have been mentioned in biogeographic studies (*e.g.*, Taylor, 1985). I will compare characteristics of shells collected from patches apparently located at two surface leaks with shells from sediments not directly associated with a leak, to determine if shells show any obvious signs of reworking, exposure, and redeposition. Results of trenching across one surface leak also are described. All gastropods and bivalves used in this study have been deposited in the Invertebrate Paleontology Collection, Academy of Natural Sciences of Philadelphia.

Point Bartlett Study Site. – Owens Lake playa is located at the southern end of Owens Valley, a Late Cenozoic graben bounded by the Sierra Nevada on the west and the Inyo Mountains on the east (Figure 1a). The lake basin occupies the widest part of the graben and is filled with over 2500 m of mostly fine-grained sediments (Smith and Pratt, 1957; Hollett *et al.*, in press). In the northwestern corner of the playa, lake beds are folded and disrupted by faults probably related to the Owens Valley fault zone (Carver, 1969). The conspicuous ridge-and-swale topography in this area is the surface expression of the folded Pleistocene beds. At Point Bartlett

Figure 1. *a*, Point Bartlett study site (star) as seen from western slope of Cerro Gordo in the Inyo Mountains, with Sierra Nevada in the background; *b*, Linear shelly patches on the playa floor (handle of digging tool is approximately 0.5 m long).

(Figure 2), these beds are predominantly lacustrine muds with minor sand and gravel interbeds of early Wisconsinan age overlain by late Wisconsinan to Holocene beach deposits, nearshore bars, and thin veneers of windblown sand and evaporitic crusts (Carver, 1975; Saint-Amand *et al.*, 1987).

Three large bulk samples were collected southeast of Point Bartlett. Three different types of shelly surface deposits were collected: 1) a linear windrow-like shelly patch apparently located above a shell leak; 2) an elliptical patch, also apparently above a leak; and 3) a shelly sediment blanket covering the face of a 1-metre-high scarp and not directly associated with any obvious Pleistocene outcrops. A total of 16 litres of shelly sediments from the three different patches were wet-sieved on a screen with 2 mm openings, and all fossils were identified, counted, and general notes made on the condition of shells. Over 7700 specimens of mollusks were recovered, including nine species of gastropods and one bivalve. A few fish bones also were recovered. Table 1 contains inventories of the samples; Plate 1 illustrates the dominant taxa.

At a linear shelly patch (star in Figure 2) a trench was dug perpendicular to the patch to a depth of 0.5 m. This exposed what appeared to be steeply-dipping, light olive gray (5 Y 5/2) clay containing two shelly sand lenses (Figure 3). If the shell lenses are indicative of primary stratification, the beds here dip 74°W and strike N6°W. Alternatively, considering the steepness of apparent bedding and the blocky, fractured fabric of the mud, these shelly layers could be clastic dikes that brought shelly sand to the playa floor from several metres below the surface. Both interpretations are plausible because lake beds are folded and faulted near Point Bartlett. Moreover, Carver (1969, Plate 2) mapped bundles of fault scarps trending nearly north-south in this same area. A third possibility is that the shelly layers are really fissures in the blocky, dessicated Pleistocene mud that were filled from above with younger lacustrine sediments.

Because the surface deposits over much of this area are gravelly sands but shelly layers exposed in the trench wall lacked

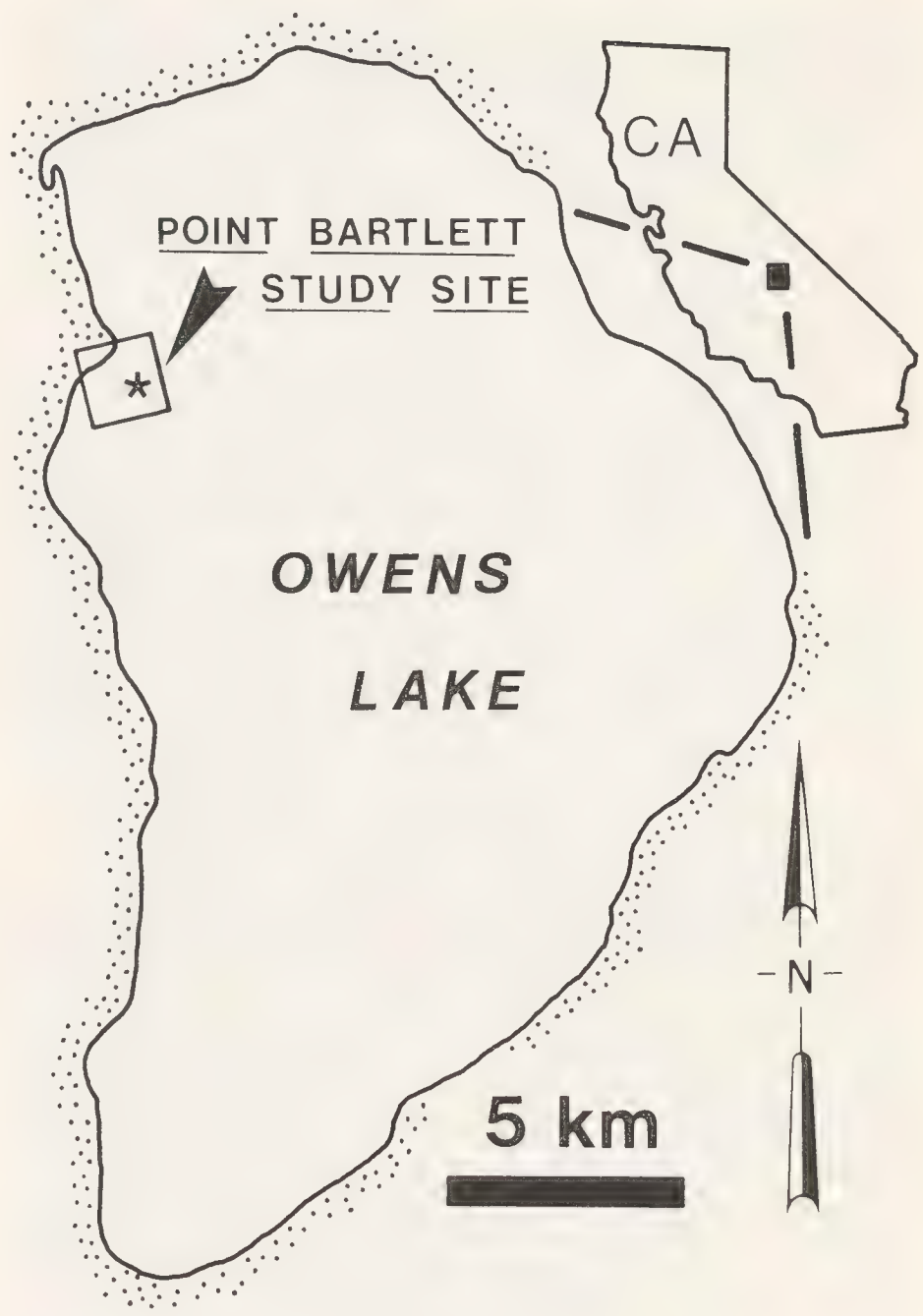

Figure 2. Location of Owens Lake playa and Point Bartlett study site. Star is location of trench shown in Figure 3.

gravel, leakage of younger into older lake beds probably can be ruled out. In addition, shell density (specimens/area of lake floor) is usually highest near the leaks, suggesting that the leaks are sources and not sinks for reworked shells. It is more difficult to determine if the trench exposed a clastic dike or steeply dipping shelly lenses. Possible evidence that the shelly layers are fracture-disrupted lenses includes grayish olive (10 Y 4/2) color mottles in the trench wall that were elongate and parallel to the lenses, suggesting stratification in the surrounding mud. At present, this particular shell leak is interpreted as the eroded limb of a fold (Figure 4). Other leaks could be clastic dikes. Only extensive trenching would decide which type of shell leakage is prevalent and the precise relationship to structural elements.

POINT BARTLETT MOLLUSKS

Taxonomic Composition. – Most of the

Figure 3. Trench dug through a linear shelly patch (*L*) showing shell lenses or possibly clastic dikes (*S*) intersecting playa floor. Pencil near edge of trench is 14 cm long.

specimens in the samples were the distinctive planorbid snails, *Helisoma newberryi* (Plate 1, figs. 1a, b) and *Vorticifex effusa* (Plate 1, figs. 3a, b). Both species are common in Quaternary deposits of western North America, with *H. newberryi* restricted to the Interior Basin Drainage (see Burch, 1982; Taylor, 1985). The widely distributed planorbid, *Gyraulus parvus* (Plate 1, fig. 4), was uncommon in the samples. Next in importance to planorbids were the valvatid snails, *Valvata utahensis* and *Valvata humeralis* (Plate 1, figs. 5 and 6). *Valvata utahensis* is another species restricted to the Interior Basin, but *V. humeralis* is more widely distributed in western North America (Burch, 1982; Taylor, 1985). A single unidentified species of *Pisidium* made a strong showing in one sample and was the only bivalve recovered (Plate 1, fig. 7). Other mollusks, including another small planorbid, at least one species of hydrobiid, a physid, and a lymnaeid, were represented by only a few specimens (Table 1).

The Owens Lake fauna described here is dominated by taxa of Taylor's (1985, Table 3) environmental "Group C", which includes snails of large freshwater lakes and permanent rivers. These taxa are *Helisoma newberryi, Valvata utahensis,* and probably *Vorticifex effusa.* Other taxa, including *Valvata humeralis, Gyraulus parvus,* and *Physa* sp., are more typical of Taylor's "Group E", snails of small or seasonal freshwater lakes and streams. This suggests that the Point Bartlett samples contain mixtures of snails from a large, fully developed lake together with snails from shallow, perhaps peripheral ponds and streams. Occurrence of the mixed molluscan fauna in sand lenses (Figure 3) might indicate overlap of the ranges of snails within the same lacustrine basin as lake level fell following a "pluvial maximum." At Owens Lake, such sand layers sometimes are succeeded vertically by gravelly intervals denoting progradation of alluvial fan deposits during interpluvial periods (G.A. Carver, person. comm.). Considering the abundance of taxa such as *Helisoma newberryi,* however, conditions must have been closer to fully pluvial when the shelly lenses were deposited, with Owens Lake forming a link in the chain of late Pleistocene intermontane lakes that occupied the Owens, China, Searles, Panamint, and Death Valley basins (see Smith and Street-Perrott, 1983, p. 197-199). The same mollusks are

Table 1. Pleistocene fossils from the floor of Owens Lake near Point Bartlett (see Figure 2).

TAXA[1]	ORGANISM TYPE[2]	HABITAT[3]	PLEISTOCENE SHELL LEAKS Linear (4.3 litres)[4]	PLEISTOCENE SHELL LEAKS Elliptical (5 litres)	SCARP FACE SAMPLE (7 litres)
Helisoma newberryi (Lea, 1858)	G : Pl	LPW	1276 (92.1%)[5]	2568 (47.7%)	559 (73.3%)
Vorticifex effusa (Lea, 1856)	G : Pl	LPW	47 (3.4)	2086 (38.7)	84 (11.0)
Valvata utahensis Call, 1884	G : Va	LPW	34 (2.5)	383 (7.1)	27 (3.5)
V. humeralis Say, 1829	G : Va	SPW	27 (1.9)	295 (5.5)	77 (10.1)
Gyraulus parvus (Say, 1817)	G : Pl	SPW	1 (0.1)	27 (0.5)	4 (0.5)
? *Amnicola* sp.	G : Hy	?	–	6 (0.1)	12 (1.6)
Physa sp.	G : Ph	SPW	–	15 (0.3)	–
? *Planorbula* sp.	G : Pl	?	–	1 (0.02)	–
Lymnaeid indet.	G : Ly	?	–	1 (0.02)	–
Pisidium sp.	B : Sp	?	223	9	37
Fish bones	T : ?	?	rare	rare	rare

1 – Sources used to identify mollusks: Henderson, 1929; Hanna 1963; Burch, 1975, 1982
2 – G : Pl = Gastropoda: Planorbidae; G : Va = Gastropoda: Valvatidae; G : Hy = Gastropoda: Hydrobiidae; G : Ph = Gastropoda: Physidae; G : Ly = Gastropoda: Lymnaeidae; B : Sp = Bivalvia: Sphaeriidae; T : ? = Teleostei: family unknown
3 – LPW = large perennial waters; SPW = seasonal or small perennial waters (after Taylor, 1985)
4 – Volume of bulk sediment sample
5 – Relative abundance of snails only

found in Quaternary deposits throughout this system of lacustrine basins (Hanna, 1963; Taylor, 1985).

Preservation of Shells. – Characteristics of the four numerically dominant snails were evaluated to identify differences between shells occurring at the leaks and shells not directly associated with a surface exposure. Criteria used in the comparison were: 1) taxonomic composition; 2) abundance of shells (specimens/litre of sediment); 3) maximum size of specimens; 4) fragmentation; and 5) surface condition and diagenetic alteration of shells. Matrix lithology also was compared. These are essentially the criteria suggested by Johnson (1960) for evaluation of taphonomic history of shelly fossil deposits.

All samples were dominated by the same four species of snails, although relative abundances varied (Table 1). Both thin, fragile shells and more robust, thicker-shelled specimens were found in all three samples. There was no obvious difference in proportion of broken shells; all samples consisted of 20-25% of specimens as fragments, and these were mostly the thin-shelled juveniles.

Abundance of shells from the linear surface leak was 322 shells/litre, while that of the elliptical leak was 1076 shells/litre. In the sample from the sediment veneer covering the scarp face, abundance was only 102 shells/litre (Table 1). All three samples contained complete growth series of the two most abundant snails, *Helisoma newberryi* and *Vorticifex effusa,* but maximum size for both species was greater in the shell leak samples. The largest *Helisoma* shells were 19.5 mm in diameter in both leak samples, but 16 mm in the scarp sample. *Vorticifex* had maximum diameters of 10.5 and 11.0 mm in the leak samples, but only 8.5 mm in the scarp material. Both the differences in abundance and maximum sizes could reflect winnowing during the erosion of Pleistocene lake beds, or could represent primary characteristics of the source deposits. The most striking difference was in diagenetic alteration of shells. Approximately 90% of shells

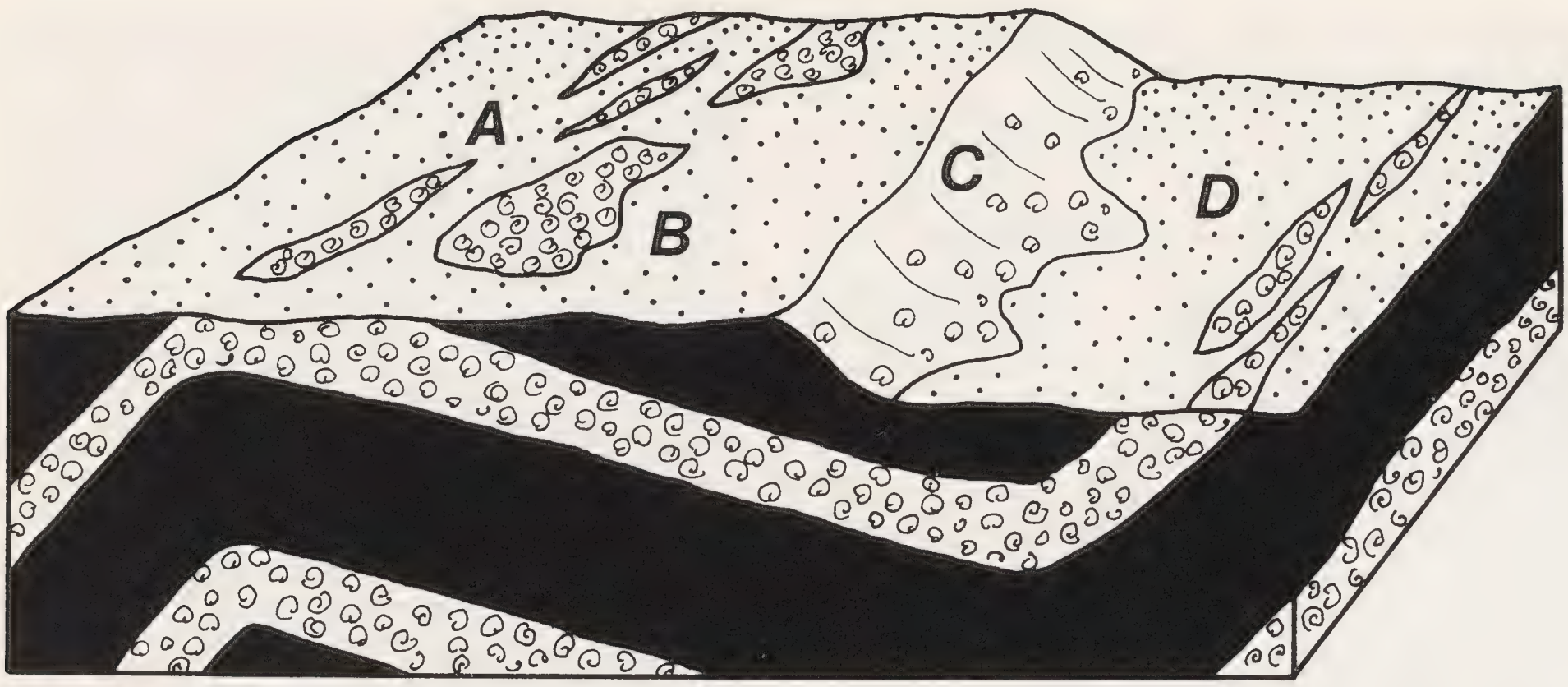

Figure 4. Interpretive block diagram showing linear shelly patches (*A*) and elliptical shelly patches (*B*) as surface leaks resulting from erosion of folded lake beds. Sparsely fossiliferous sediment covers the face of a small scarp (*C*) and pebbly sand surrounds all the shelly areas (*D*). (Not drawn to scale.)

from the scarp sample were discolored (Plate 1, fig. 2), resembling "black shells" from palimpsest and relic deposits on modern marine continental shelves (Pilkey *et al.*, 1969). Fewer than 5% of the shells in the other samples were blackened. As in the case of continental shelf fossils, the discoloration is probably the result of partial replacement by iron monosulphide and pyrite. Mollusk shells collected from anaerobic zones of modern lakes typically are blackened in this way (A. E. Bogan, person. comm.). Finally, the matrix in the leak samples was olive gray (5 Y 3/2), fine-medium sand; the scarp was covered with olive brown (5 Y 4/4) to yellowish gray (5 Y 7/2), pebbly sand.

Although the differences between near-source samples and material not directly associated with an outcrop seem fairly clear here, it is not known if characteristics such as diagenetic alteration are reliable guides to prolonged exposure of shells. In fact, any of the characteristics mentioned above could have been imprinted on the shells from the scarp sample prior to the late Pleistocene or Holocene erosion and redistribution. There is still the preliminary indication, however, that shells not directly associated with a leak show more signs of exposure and alteration, suggesting a more complex taphonomic history compared to shells from near outcrops.

SIGNIFICANCE

Lacustrine paleoecology is undergoing a revival, as shown by the number of recent papers, symposia, and entire journal numbers dedicated to the biota of lakes (*e.g.*, Smiley, 1985; Forester, 1987; Gray, 1988). In step with this revival of interest is an increasing awareness of the taphonomic problems unique to different types of lakes and to varied lacustrine depositional envi-

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PLATE 1

Figures

1 a, b. *Helisoma newberryi* (Lea). Height 6.5 mm, diameter parallel to aperture 7.0 mm.
2. Blackened apical fragment of *H. newberryi*. Width measured horizontally 8.0 mm. Compare with 1b.
3 a, b. *Vorticifex effusa* (Lea). Height 4.5 mm, diameter 7.5 mm.
4. *Gyraulus parvus* (Say). Diameter 2.9 mm.
5. *Valvata utahensis* Call. Height 3.7 mm.
6. *Valvata humeralis* Say. Height 2.5 mm.
7. *Pisidium* sp. Height 3.3 mm, length 3.2 mm.

PLATE 1

ronments. The shell leaks at the floor of Owens Lake playa illustrate a potentially important process of reworking that could influence the compilation of fossil sequences in tectonically active lacustrine basins. This type of reworking would go unnoticed if angular unconformities are not obvious, if incompatible environmental signals (*e.g.*, snails of large freshwater lakes + littoral bedforms and beach deposits + evaporitic crusts) are not detected, or in cases where mollusks have long stratigraphic ranges. As shown in this study, it may not be possible to identify unequivocally reworked shells based solely on the condition of specimens, although it is likely that reworked and redistributed material will be altered in ways suggestive of recycling (*e.g.*, size-sorting, fragmentation, and possibly black shells). Temporal mixing would be especially hard to detect in subsurface cores that sample thick sequences of mostly massive muds (see Smith and Pratt, 1957). Reworking of mollusks on this scale does not merely blend many generations of organisms or the fauna of different benthic communities into time-averaged assemblages, but could result in the comingling of fossils from different pluvial cycles.

ACKNOWLEDGMENTS

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REFERENCES CITED

BURCH, J. B., 1975, Freshwater Sphaeriacean Clams (Mollusca: Pelecypoda) of North America: Malacological Publ., Hamburg, Michigan, 96 p.

BURCH, J. B., 1982, Freshwater Snails (Mollusca: Gastropoda) of North America: U.S. Environ. Protect. Agency, Environ. Monitoring and Support Lab., EPA - 60013 - 82 - 026, Cincinnati, 294 p.

CARVER, G. A., 1969, Quaternary Tectonism and Surface Faulting in the Owens Lake Basin, California: Unpubl. M.S. Thesis, Univ. Nevada - Reno, 150 p.

CARVER, G. A., 1975, Shoreline deformation at Owens Lake: Calif. Geol., v. 28, p. 111.

FORESTER, R. M. (ed.), 1987, Paleo-Lacustrine Theme Issue: Palaios, v. 2, p. 412-522.

GRAY, J. (ed.), 1988, Paleolimnology: Aspects of Freshwater Paleoecology and Biogeography: Palaeogeogr., Palaeoclimat., Palaeoecol., v. 62, 678 p.

HANNA, G. D., 1963, Some Pleistocene and Pliocene freshwater Mollusca from California and Oregon: Occas. Pap. Calif. Acad. Sci., no. 43, 20 p.

HENDERSON, J., 1929, The non-marine Mollusca of Oregon and Washington: Univ. Colorado Stud., v. 17, p. 47-190.

HOLLETT, K. J., W. R. DANSKIN, W. F. MC CAFFREY, and C. L. WALTI, *in press*, Hydrogeology and water resources of Owens Valley, California: U.S. Geol. Survey, Water-Supply Paper.

JOHNSON, R. G., 1960, Models and methods for analysis of the mode of formation of fossil assemblages: Bull. Geol. Soc. America, v. 71, p. 1075-1086.

PILKEY, O. H., B. W. BLACKWELDER, L. J. DOYLE, E. ESTES, and P. M. TERLECKY, 1969, Aspects of carbonate sedimentation on the Atlantic Continental Shelf off the southern United States: Jour. Sed. Petrol., v. 39, p. 744-768.

SAINT-AMAND, P., C. GAINES, and D. SAINT-AMAND, 1987, Owens Lake, an ionic soap opera staged on a natric playa, *in* M. L. HILL, ed., Centennial Field Guide, Volume 1, Cordilleran Section, Geol. Soc. America, p. 145-150.

SMILEY, C. J. (ed.), 1985, Late Cenozoic History of the Pacific Northwest: Amer. Assoc. Adv. Sci., Pacific Div., San Francisco, 417 p.

SMITH, G. I. and W. P. PRATT, 1957, Core logs from Owens, China, Searles, and Panamint basins, California: U. S. Geol. Survey, Bull. 1045-A, 62 p.

SMITH, G. I., and F. A. STREET-PERROTT, 1983, Pluvial lakes of the western United States, *in* S. C. PORTER, ed., Late-Quaternary Environments of the United States. Vol. 1. The Late Pleistocene: Univ. Minnesota Press, Minneapolis, p. 190-212.

TAYLOR, D. W., 1985, Evolution of freshwater drainages and mollusks in western North America, *in* C. J. SMILEY, ed., Late Cenozoic History of the Pacific Northwest: Amer. Assoc. Adv. Sci., Pacific Div., San Francisco, p. 265-321.

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ANATIPOPECTEN AND THE ROTULARIA VERNONI ZONE (LATE EOCENE) IN PENINSULAR FLORIDA

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One of the best guide fossils found in the Late Eocene *Rotularia vernoni* Zone (*Asterocyclina-Spirulaea vernoni* Zone of Puri, 1957) in peninsular Florida is a species of *Anatipopecten* (Plate 1). The ribs of this pectinid are so different from other pectens found in the Ocala Group that even a fragment can be easily recognized as *Anatipopecten*. This distinctive pectinid is common but not abundant in the *Rotularia vernoni* Zone of the Crystal River Formation; yet, it remains relatively poorly known. Our objectives in this paper are three-fold; 1) to describe the range of morphologic variation in this bivalve; 2) to consider its proper species assignment; and 3) to discuss its distribution and occurrence in the *Rotularia vernoni* Zone. There are about 80 specimens of *Anatipopecten* (including fragments) in the invertebrate paleontology collection at the Florida State Museum (FSM). Of these 57 were complete enough to make rib counts and 52 could be measured for height and length. These specimens formed the basis for this study.

Hertlein (1936) proposed *Anatipopecten* as a section with *Pecten anatipes* Morton, 1833, as the type species. Our specimens are similar enough to the type species that there is no doubt they are a species of *Anatipopecten*. Anatipopectens are, in general, small-sized pectinids. The largest specimen in the FSM collection is only 33.4 mm high and 29.8 mm long, and only five other specimens are over 30.0 mm in either height or length. The average size of the specimens is 22.8 mm in height and 22.2 mm in length. The smallest specimen is 13.5 mm in height and 12.5 mm in length. Approximately 80% of the 52 specimens are higher than long. The size of our specimens is about the same as that of *Chlamys (Anatipopecten) anatipes* reported by Dockery (1982) from the Vicksburg Oligocene of Mississippi and by Glawe (1974) from the Oligocene of Georgia.

The number of large radial ribs on our specimens ranges from four to 12 with an average rib count of 7.5. The ribs may or may not be wider than the inerspaces and both lack pronounced radial striae, although a few specimens possess faint radial striae on the ribs. There seems to be no correlation between the size of the specimen and the number of ribs. The riblets on the auricles vary in number and size, and one specimen has no riblets on the posterior auricle.

Species determination for our specimens of *Anatipopecten* has been a problem. Hoganson (1972) allocated the specimens from peninsular Florida to *Chlamys (Lyropecten) incertae* Tucker-Rowland, 1938. This species is based on a single right valve (the holotype) collected by Druid Wilson from railroad ballast in Polk County, Florida (pers. commun., 1988). The *Rotularia vernoni* Zone does occur at two locations in northwestern Polk County. However, Tucker-Rowland (1938) stated that the specimen was found near Ocala, Florida, but the nearest locality

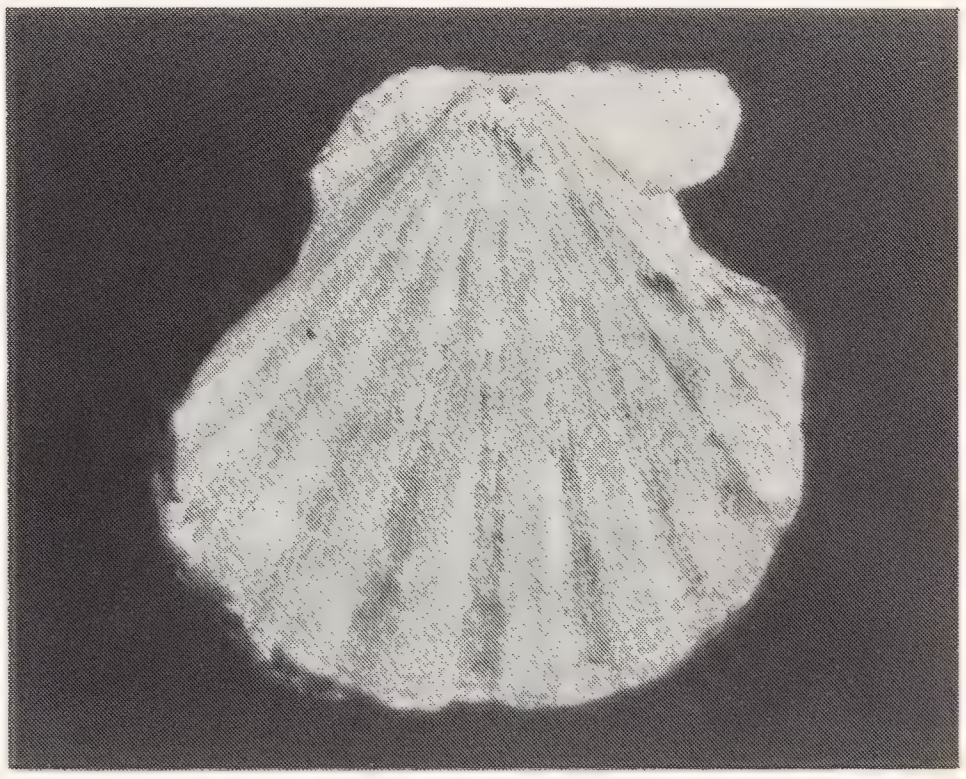

Figure 1. *Chlamys (Lyropecten) incertae* Tucker-Rowland, 1938. Holotype (FMNH 51872). Right valve exterior, height 24.0 mm, length 23.3 mm.

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Figure 2. Map of Florida with the two NW-SE trending regions of outcrops (circles) of the *Totularia vernoni* Zone. D represents an outcrop of the *Rotularia vernoni* Zone in a structural low in Dixie County. J is in Jackson County where the *Rotularia vernoni* Zone has been reported (Puri, 1957) but both *Chlamys (Anatipopecten) incertae* and *Rotularia vernoni* are absent.

where the *Rotularia vernoni* Zone occurs is at Orange Lake in northern Marion County, about 15 miles north of Ocala. The region around Ocala appears to be a structural high (Nicol *et al.*, 1976).

We were able to borrow the type specimen from the Field Museum of Natural History (FMNH), where it had been transferred from the University of Chicago, (see Palmer and Brann, 1965). This specimen had been questionably listed as the holotype because Tucker-Rowland had given the measurements of the type as 26.0 mm high and 21.0 mm long, whereas the actual specimen is 24.0 mm high and 23.3 mm long. Furthermore, in the plate explanation, Tucker-Rowland stated that the magnification of the specimen was 2/3X, but the photograph is actually magnified about 1.6X. We compared the specimen

from the FMNH (Text-fig. 1) with the original photograph and there is no doubt that the specimen is the holotype. However, a portion of the posterior auricle has been broken off since the original photograph was made.

Chlamys (Anatipopecten) incertae differs from other species of *Anatipopecten* in that it lacks well-developed secondary radial striae on the primary ribs and also on the interspaces. Specimens from Jackson County Florida, have well-developed striae on the ribs and interspaces. The holotype of *Chlamys (Anatipopecten) incertae* does not possess secondary radial striations on the ribs and interspaces and is, thus, similar to our specimens. The holotype has 11 primary ribs and the interspaces are narrower than in most of our specimens. However, the size and other features of the shell are comparable. *Chlamys (Anatipopecten) incertae* appears to be confined to peninsular Florida.

The general pattern of outcrops of the *Rotularia vernoni* Zone in peninsular Florida is divided into two belts to northwestwardly trending regions. The northern region consists of Lafayette, Suwannee, Alachua, Dixie, and the northern tip of Marion County. The outcrop of the *Rotularia vernoni* Zone in northwestern Dixie County is in a structural low and appears out of place for this reason. This locality is marked D on the map in Text-fig. 2. The farthest north this zone crops out is on the banks of the Suwannee River at Ellaville in northwestern Suwannee County. The northern region of outcrops is separated by an area of the Ocala Group below the *Rotularia vernoni* Zone and includes almost all of Marion and Dixie counties and all of Levy and Gilchrist counties. The outcrop of the southern region is more symmetrical than in the northern region, and it includes Citrus, Hernando, Sumter, and northwestern Polk County. Discovery of more outcrops of the *Rotulari vernoni* Zone on the surface, in limestone quarries, or along rivers will probably not substantially change the present known outcrop pattern.

The thickest section of the *Rotularia vernoni* Zone measured by Hoganson (1972) was 40 ft, or 10 m, in Suwannee County. The zone appears to be thicker in the northern counties of Suwannee and Lafayette than it is to the south in Citrus, Hernando, Sumter, and Polk counties, where it is rarely more than 10 ft, or 3 m. Hoganson found only eight complete measurable sections of the *Rotularia vernoni* Zone.

Puri (1957) reported the *Rotularia vernoni* Zone from Jackson County near Marianna, Florida. This area is north and west of the outcrops in peninsular Florida and is marked by the letter J on the map. These beds may not be the same age as those in peninsular Flodia because the faunas in the two areas have some striking differences. Specimens of *Anatipopecten* from Jackson County do not appear to be *Chlamys (Anatipopecten) incertae*. *Asterocyclina* is abundant and some specimens are large in Jackson County, but *Asterocyclina* is rare and the specimens are all small in peninsular Florida. Also, *Rotularia vernoni* does not occur in Jackson County but is common in peninsular Florida.

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LITERATURE CITED

DOCKERY, D. T., III, 1982, Lower Oligocene Bivalvia of the Vicksburg Group in Mississippi: Mississippi Department of Natural Resources Bureau of Geology, Bulletin 123, 261 p., 62 pls.

GLAWE, L. N., 1974, Upper Eocene and Oligocene Pectinidae of Georgia and their stratigraphic significance: Georgia Dept. Nat. Resources, Earth and Water Division, Geol. Surv. Georgia, Information Circular 46, 27 p., 4 pls.

HERTLEIN, L. G., 1936, Three new sections and rectifications of some specific names in the Pectinidae: Nautilus, vol. 50, nos. 1 & 2, p. 24-27, 54-58.

HOGANSON, J. W., 1972, The *Spirulaea vernoni* Zone of the Crystal River Formation (Upper Eocene) in Peninsular Florida: Unpubl. M.S. thesis, Dept. Geol., Univ. Florida, 69 p., 9 figs., 4 pls.

NICOL, DAVID, G. D. SHAAK, and J. W. HOGANSON, 1976, The Crystal River Formation (Eocene) at Martin, Marion County, Florida: Tulane Stud. Geol. Paleont., vol. 21, no. 3, p. 137-144.

PALMER, K. V. W., and D. C. BRANN, 1965, Catalogue of the Paleocene and Eocene Mollusca of the Southern and Eastern United States. Part I. Pelecypoda, Amphineura, Pteropoda, Scaphopoda, and Cephalopoda: Bulls. Amer. Paleontology, vol. 48, no. 218, 466 p.

PURI, H. S., 1957, Stratigraphy and Zonation of the Ocala Group: Florida Geol. Surv., Bull. 38, 248 p.

TUCKER-ROWLAND, H. I., 1938, The Atlantic and Gulf Coast Tertiary Pectinidae of the United States. Section III. Systematic Descriptions: Mém. Musée Roy. Hist. Nat. Belgique, Deuxiéme Fasc. 13., 76 p., 6 pls.

WILLIAMS, K. E., DAVID NICOL and A. F. RANDAZZO, 1977, The Geology of the Western Part of Alachua County, Florida: Rept. Investigations No. 85, Florida Bureau of Geology, 98 p.

September 20, 1989

PLATE 1

Chalmys (Anatipopecten) incertae Tucker-Rowland. All specimens deposited in the Florida State Museum, University of Florida.

Figures

1, 6. 1. Left valve exterior, height 26.8 mm, length 26.6 mm, (UF 3305) hypotype.
6. Left valve interior, height 30.0 mm, length 28.9 mm, (UF 3306) hypotype. Locality of specimens 1,6: Lafayette County, quarry complex 0.5 miles west of bridge on Suwannee River and 0.5 miles north of S-250, approximately 2 miles west of Dowling Park. N 1/2, Sec. 6, T3S, R11E.

2-5. 2. Right valve exterior. 3. Right valve interior, height 20.9 mm, length 20.2 mm (UF 3307) hypotype. 4. Left valve exterior. 5. Left valve interior, height 18.9 mm, length 18.7 mm, (UF 3308) hypotype. Locality of specimens 2-5: Polk County, abandoned quarry 1.6 miles south of Withlacoochee River and just east of state highway 471. SW 1/4 Sec. 19, T25S, R23E.

PLATE 1

VIGNETTES OF COASTAL PLAIN GEOLOGY

WILLIAM HEALEY DALL
(1845-1927)

The single greatest name in American Tertiary Paleontology is, without question, William Healey Dall, whose work spanned over seventy years (his last paper was not published until nine years after his death). In his career he introduced over 5,000 molluscan taxa. A study of the choice of specific names is a good indication of the importance to his work in the Coastal Plain, *e.g.,: chipolana-us* (53), *floridana-us* (33), *caloosaense-is* (16). His first scientific job was as a naturalist in Alaska, where at age 21 he was chosen to replace the director of scientific work, who collapsed from heart failure brought on by overwork and the stress of the expedition. In 1868, at the end of the expedition, he returned to the Smithsonian Institution to work on the collections and write up the results. He was appointed Honorary Curator of the Division of Mollusks and Tertiary Fossils, a post he held until his death in 1927. In 1884 he joined the newly formed U.S. Geological Survey as Paleontologist and it was in this guise that he made his single most important contribution to Coastal Plain Geology – *Contributions to the Tertiary fauna of Florida* (1890-1903, in 6 parts with 1654 pp. and 60 plates). (*From* P. Bartsch, H. A. Rehder, and B. E. Shields, 1947, Smithsonian Miscellaneous Collections, vol. 104, no. 15)

OSTRACODA OF THE MOCTEZUMA FORMATION, PLIOCENE, NICOYA PENINSULA, COSTA RICA

W. A. VAN DEN BOLD
LOUISIANA STATE UNIVERSITY, BATON ROUGE

ABSTRACT

Although Recent ostracodes of the Pacific coast of the Americas have been extensively studied, Pliocene faunas have only been reported from Chile, California, and recently from Mexico. In this paper fifty species are recorded from the Moctezuma Formation of the Nicoya Peninsula of Costa Rica, the first time that a direct comparison can be made of ostracode faunas on both sides of the Central American land bridge. Ten of the species are known only from the Caribbean, thirteen only from the Pacific and ten have been found on both sides. The ostracode fauna indicates an early Pliocene age (confirmed by planktonic foraminifera) and deposition in an inner to middle shelf environment. The study suggests that in the early Pliocene a shallow water connection existed between the Caribbean and the Pacific Ocean.

A study of the foraminifera of Puntarenas Province, Costa Rica (McKee, 1985) included the Moctezuma Formation. McKee gave the ostracodes found to me for identification and, thereby, gave me

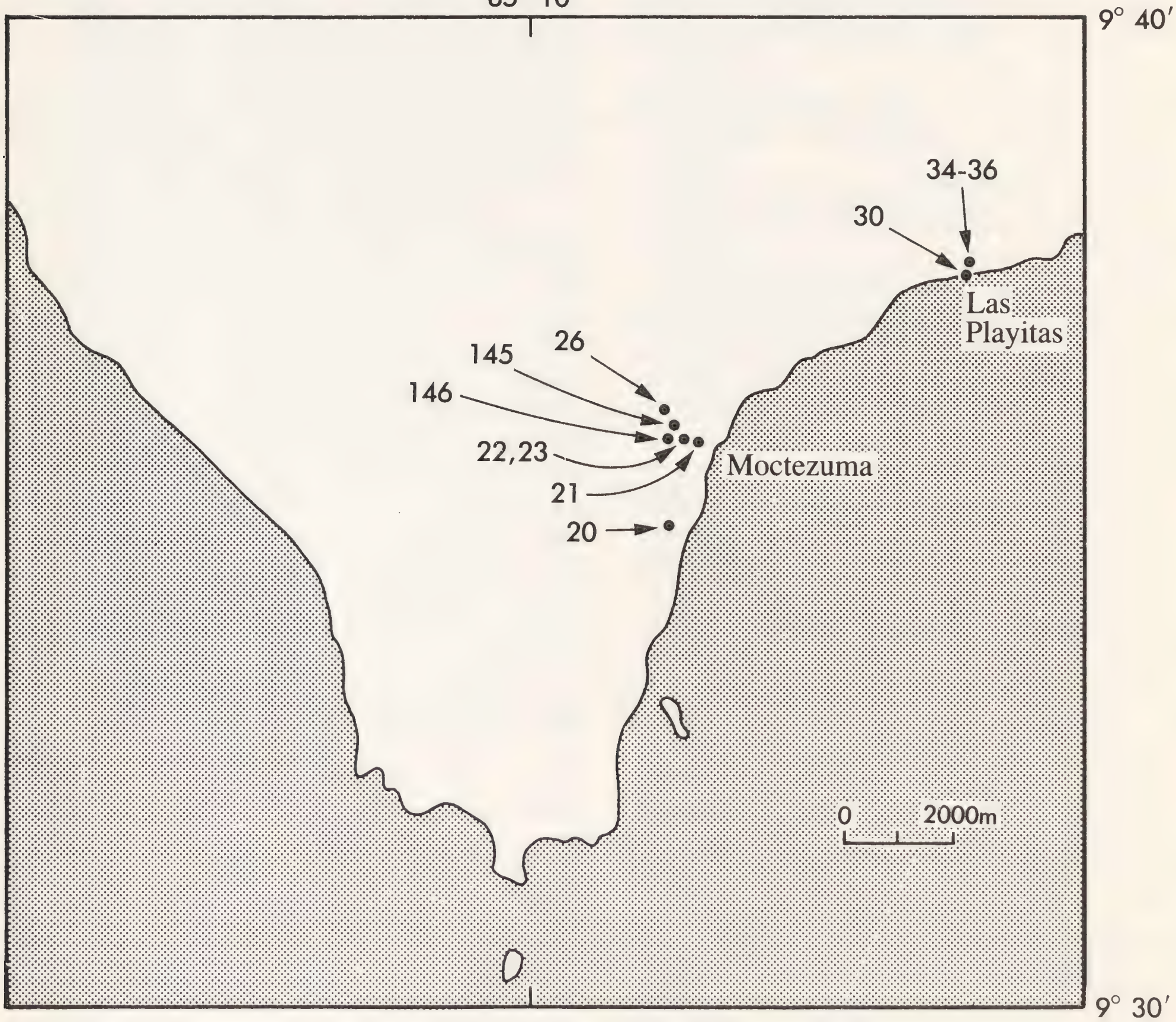

Figure 1. Location map of samples of the Moctezuma Formation on the east side of the Nicoya Peninsula, Costa Rica.

the opportunity to report for the first time on Pliocene ostracodes from the Pacific side of Central America. The fossil record of ostracodes here is very poor and preservation generally bad, presumably due in part to the volcanoclastic nature of the sediments, except in those rocks that were deposited subsequent to the major tectonic events, such as the Moctezuma Formation. I had previously collected two samples from this formation, but reported only very briefly on them (Bold, 1967, p. 75), and some samples from the Pacific side of Nicaragua, only two of which contained any ostracodes: one from the El Fraile Formation (Miocene), containing *Cytherella* sp., *Cytherelloidea* sp. and *Costa baracoloradensis* Bold, 1967, and one from the El Salto Formation (lower Pliocene, Woodring, 1976), containing *Cytherella* sp. and *Coquimba?* sp. For a comparison with the Pliocene Pacific fauna we have to go either far north to Maria Madre Island, Mexico (Carreño, 1985) and California (LeRoy, 1943, Crouch, 1949) or far south to Chile (Ohmert, 1968, 1971).

The Moctezuma Formation unconformably overlies the Nicoya Complex, and the Sabana Grande and Rivas formations. It consists of a 1-3 m thick basal conglomerate with chert and basalt clasts, overlain by medium to coarse grained sandstone, with horizons of mollusk fragments. Total thickness in the Moctezuma area is about 50 m, but according to Lundberg (1982) it thickens towards the south to 120 m.

Of the 50 species of ostracodes 10 have been reported only from the Caribbean, 13 only from the Pacific, while 10 have been found on both sides of the Central American landbridge. Sixteen species are not identified with either group. Caribbean forms in the Moctezuma Formation generally range from late Miocene or early Pliocene to Recent (Table 1), *Loxoconcha cyrton* Bold (late Miocene to early Pleistocene) and *Kangarina quellita* Coryell and Fields (Miocene to early Pliocene). As *K. quellita* occurs only in the Playitas sections and *K. ancyla* Bold (early Pliocene - Recent) only in the upper part of the Moctezuma section, this suggests that the two sections are penecontemporaneous and early Pliocene in age, which is confirmed by the planktonic foraminifera (zone N 18).

Nine of the species are reported by Carreño (1985) from Maria Madre Island, off the Pacific coast of Mexico. However, the two new species of *Radimella* described by her do not occur in the Moctezuma Formation. Instead one of the two species there is Caribbean (*R. confragosa,* latest Miocene to Recent), while the other one is related to the Recent Galápagos fauna described by Pokorný (1962).

In conclusion, the presence of Caribbean shallow marine ostracodes in the lower Pliocene of the Nicoya Peninsula suggests that as late as early Pliocene a shallow connection existed between the Caribbean Sea and the Pacific Ocean.

Based on an upward increase in number of specimens of *Cassidulina subglobosa* Brady, and the presence of deep water species, such as *Bolivina pacifica* Cushman and McCullock, *Epistomella exigua* (Brady), *Uvigerina incilis* Todd, and others, McKee (1985) suggests an outer shelf to upper slope environment of deposition, into which inner and middle shelf species, such as *Bulminella elegantissima* (d'Orbigny), *Discorbis parkeri* Natland, *Elphidium gunteri* Cole, *Hanzawai concentrica* (Cushman) and *Ammonia parkinsoniana* (d'Orbigny), and others, were transported. The ostracodes give no indication of anything deeper than middle shelf and in the Las Playitas section there are even some brackish water species present. All these may, of course, have been transported into deeper water, but the total absence of outer shelf to slope species and the fact that all adult specimens of the more common ostracodes (*Bairdia, Loxoconcha, Paracytheridea*) are accompanied by several molt stages, makes transport over longer distances highly improbable. Molt stages tend to be transported by lesser currents than the adult species, thus finding them together is generally an indication of no, or very short, transport. In view of this conflicting micropaleontological evidence I see no reason to deviate from Lundberg's opinion, that the Moctezuma Formation is a nearshore to offshore environment with the conglomerates and shelly beds representing high energy environment.

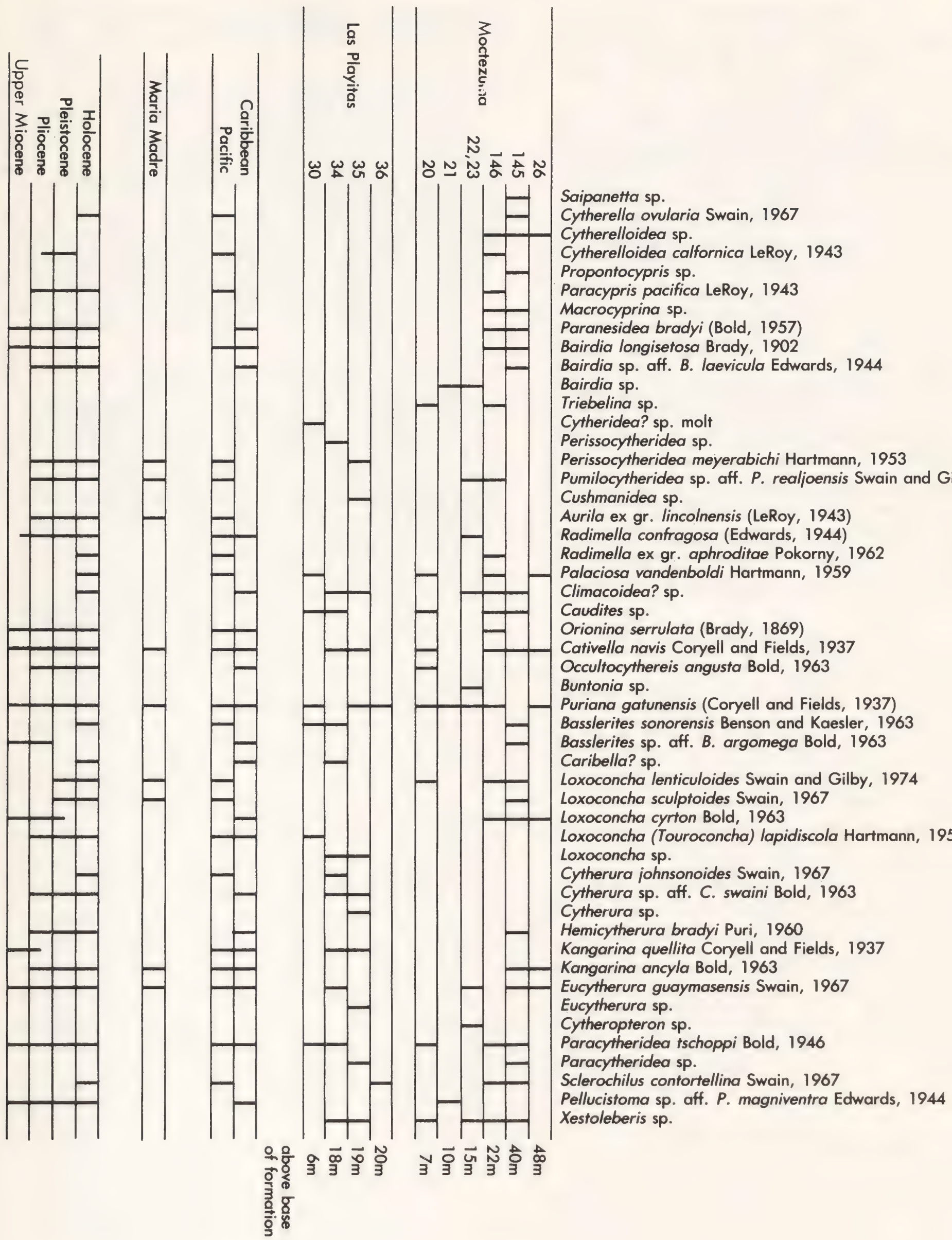

Table 1. Distribution of Ostracoda in the Moctezuma Formation (Pliocene, Pacific coast, Costa Rica), indicating their known distribution, stratigraphic range, and which species have been found in the Pliocene of Maria Madre Island, Mexico.

REFERENCES

BOLD, W. A. VAN DEN, 1967, Miocene Ostracoda from Costa Rica: Micropaleontology, vol. 13, no. 1, p. 75-86, 2 pls.

CARREÑO, A. L., 1985, Biostratigraphy of the late Miocene to Pliocene on the Pacific island Maria Madre, Mexico: Micropaleontology, vol. 32, no. 2, p. 139-166, pls. 1-6, 7 text-figs.

CROUCH, R. W., 1949, Pliocene Ostracoda from southern California: Jour. Paleontology, vol. 23, no. 6, p. 594-599, pl. 96.

LEROY, L. W., 1943, Pleistocene and Pliocene Ostracoda of the coastal region of southern California: Jour. Paleontology, vol. 17, no. 4, p. 254-273, pls. 58-62.

LUNDBERG, N., 1982, Evolution of the slope landward of the Middle America Trench, Nicoya Peninsula, Costa Rica, *In:* J. K. LEGGETT (edit.), Trench Forearc Geology: Sedimentation and Tectonics on Modern and Ancient Active Plate Margins. Blackwell Scientific Publications, Oxford, p. 131-147.

MCKEE, W. N., 1985, Tertiary foraminifera of Puntarenas Province, Costa Rica. M. S. thesis, Louisiana State University, Baton Rouge, p. 1-279, pls. 1-21, 18 text-figs., 4 tables.

OHMERT, W., 1968, Die Coquimbinae, eine neue Unterfamilie der Hemicytheridae (Ostracoda) aus dem Pliocän von Chile: Mitteilungen Bayerischen Staatssammlung, Paläontologie, Historisch Geologie, vol. 8, p. 127-165, 34 text-figs.

OHMERT, W., 1971, Die Ostracodengattungen *Palociosa* and *Caudites* aus dem Pliocän von Chile: Mitteilungen Bayerischen Staatssammlung, Paläontologie, Historisch Geologie, vol. 11, p. 87-116, pls. 9, 10, 21 text-figs.

PORKORNÝ, V., 1969, The genus *Radimella* Porkorný, 1969 (Ostracoda, Crustacea) in the Galapagos Islands: Acta Universitatis Carolinae, Geologia, no. 4, p. 293-334, pls. 1-6, 39 text-figs.

WOODRING, W. P., 1976, Age of the El Salto Formation of Nicaragua: Publicación ICAITI, no. 5, p. 18-21.

September 20, 1989

TORTAGUTTUS, A NEW UNILOCULAR FORAMINIFERAL GENUS

REESE E. BARRICK[1], AIMEE E. BEVERIDGE[1],
R. TIMOTHY PATTERSON[2], JENNIFER K. SCHUBERT[1]

ABSTRACT

A new genus of unilocular foraminifera, *Tortaguttus*, is described, with *Entosolenia sigmoidella* var. *timmsensis* Cushman and Gray, 1946, as type species. The distinctive twisted carinae and radial aperture differentiate the new genus from other genera of the subfamily Ellipsolageninae A. Silvestri, 1923.

INTRODUCTION

Entosolenia sigmoidella var. *timmsensis* Cushman and Gray 1946, was most recently assigned to the genus *Solenina* Jones, 1984 (junior synonym of *Lagnea* Popescu, 1983) and elevated from subspecies to species status (Patterson and Richardson, 1987). This species bears highly characteristic twisted carinae and possesses a radiate aperture, traits not recognized in previously established hyaline calcareous unilocular genera, *e.g.*, *Lagnea* Popescu, 1983, or *Lagenosolenia* McCulloch, 1977.

Twenty-nine specimens of the type species of the new genus were found in sediment collected from the Bathhouse Beach locality of the Pleistocene Santa Barbara Formation, Santa Barbara, California. Samples from ten different horizons within the lower member of the Santa Barbara Formation at 2.4, 7.5, 8.9, 9.6, 10.9, 15.4, 17.8, 19.7, 21.5, and 23.1 meters above the base of the section, contained the species. Two are illustrated as hypotypes (USNM 409097 and 409098). Specimens were examined with both plain light and scanning electron microscopy (SEM).

SYSTEMATIC PALEONTOLOGY

Suprageneric classification partially follows Loeblich and Tappan, 1987.

Order FORAMINIFERIDA
Eichwald, 1830

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Family ELLIPSOLAGENIDAE
A. Silvestri, 1923
Subfamily ELLIPSOLAGENINAE
A. Silvestri, 1923

Description: Test unilocular, bilateraly symmetrical: the terminal aperture may be slitlike, oval, rounded or radiate, and is provided with an entosolenian tube.

Remarks: Tortaguttus timmsensis has been assigned to the subfamily Ellipsolageninae because of the compressed test; however, the description in Loeblich and Tappan (1987) also lists the presence of a slitlike aperture as characteristic of Ellipsolageninae. We suggest that the aperture shape is less important than test shape for differentiating the subfamilies Ellipsolageninae A. Silvestri 1923, and Oolininae Loeblich and Tappan, 1961, for the following reasons.

1. Species presently placed in such genera as *Fissurina* Reuss, 1850, and *Lagenosolenia* McCulloch, 1977, show a wide variation in apertures, ranging from circular to oval to slitlike, yet all are placed in the subfamily Ellipsolageninae.
2. Radiate and round apertures intergrade due to gametogenesis; more practically, the presence of a radiate aperture is hard to determine in many species, such as the present one, except with the SEM.

For these reasons we conclude that test symmetry is a more suitable characteristic for differentiating the subfamilies Oolininae and Ellipsolageninae. The definition of the subfamily Ellipsolageninae is herein emended, as above.

TORTAGUTTUS n. gen.

Type species: Entosolenia sigmoidella (Cushman) var. *timmsensis* Cushman and Gray, 1946, p. 30, pl. 15, figs. 34-36.

Etymology: From the Latin *torto*, twist + *guttus*, narrow necked flask, gender masculine.

Diagnosis: A genus of Ellipsolageninae characterized by one or more spiralling lateral carinae and a terminal radiate aperture.

Description: Test free, unilocular, elongate, compressed in cross section; wall calcareous, hyaline, smooth, finely perforate; a marginal sigmoidal carina extends from the aperture to the base; aperture radiate within a phialine lip provided with an internal entosolenian tube.

Remarks: Our specimens of the type species were compared to SEM illustrations of topotypes (Patterson and Richardson, 1987), and appear conspecific. *Tortaguttus* differs from *Lagenosolenia, Pseudosolenia* Jones, 1984, *Lagnea* and *Vasicostella* Patterson and Richardson, 1987, in having a radiate terminal aperture and sigmoidal marginal carinae. *Lagena sigmoidella* Cushman, 1933, also should be included in the new genus *Tortaguttus*.

TORTAGUTTUS TIMMSENSIS
(Cushman and Gray)
Plate 1, figures 1-8.

Entosolenia sigmoidella (Cushman) var. *timmsensis* CUSHMAN and GRAY, 1946, p. 30, pl. 5, figs. 34-36.

Solenina timmsensis (Cushman and Gray) PATTERSON and RICHARDSON 1987, p. 220, pl. 3, figs. 4-9; pl. 5, fig. 8.

Diagnosis: A species of *Tortaguttus* characterized by an elongate neck and cross struts ornamenting the carina.

Description: Test free, unilocular, hyaline, smooth, finely perforate, elongate, compressed in cross-section, wall calcareous, two double or marginal sigmoidal carinae, connected by numerous struts, extend from the aperture to the base where the carinae are discontinuous; aperture terminal and radiate within a phialine lip, at the end of an elongate neck and provided with a short straight entosolenian tube.

ACKNOWLEDGMENTS

Support for use of the Scanning Electron Microscope was provided through National Science Foundation Grant EAR-8306170 to Alfred R. Loeblich, Jr. and Helen Tappan. We also thank ARL and HT for critically reviewing this manuscript.

LITERATURE CITED

CUSHMAN, J.A., 1933, The Foraminifera of the tropical Pacific-collections of the "Albatross," 1899-1900: U.S. Natl. Mus., Bull. 161, 75 p.

CUSHMAN, J.A., and H. B. GRAY, 1946, A foraminiferal fauna from the Pliocene of Timm's Point, California: Cont. Cushman Lab. Foram. Resh., Spec. Publ. 19, 46 p.

LOEBLICH, A. R., Jr. and H. TAPPAN, 1987, Foraminiferal genera and their classification. Van Nostrand Reinhold Co., New York 2047, p. (2 volumes).

MCCULLOCH, I., 1977, Qualitative observations on Recent foraminiferal tests, with emphasis on the eastern Pacific, Part 3: Univ. Southern California Press, Los Angeles, 1079 p.

PATTERSON, R. T., and R. H. RICHARDSON, 1987, A taxonomic revision of the unilocular foraminifera: Jour. Foram. Resh., v. 17, p. 212-226.

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PLATE 1
Tortaguttus timmsensis n. gen.

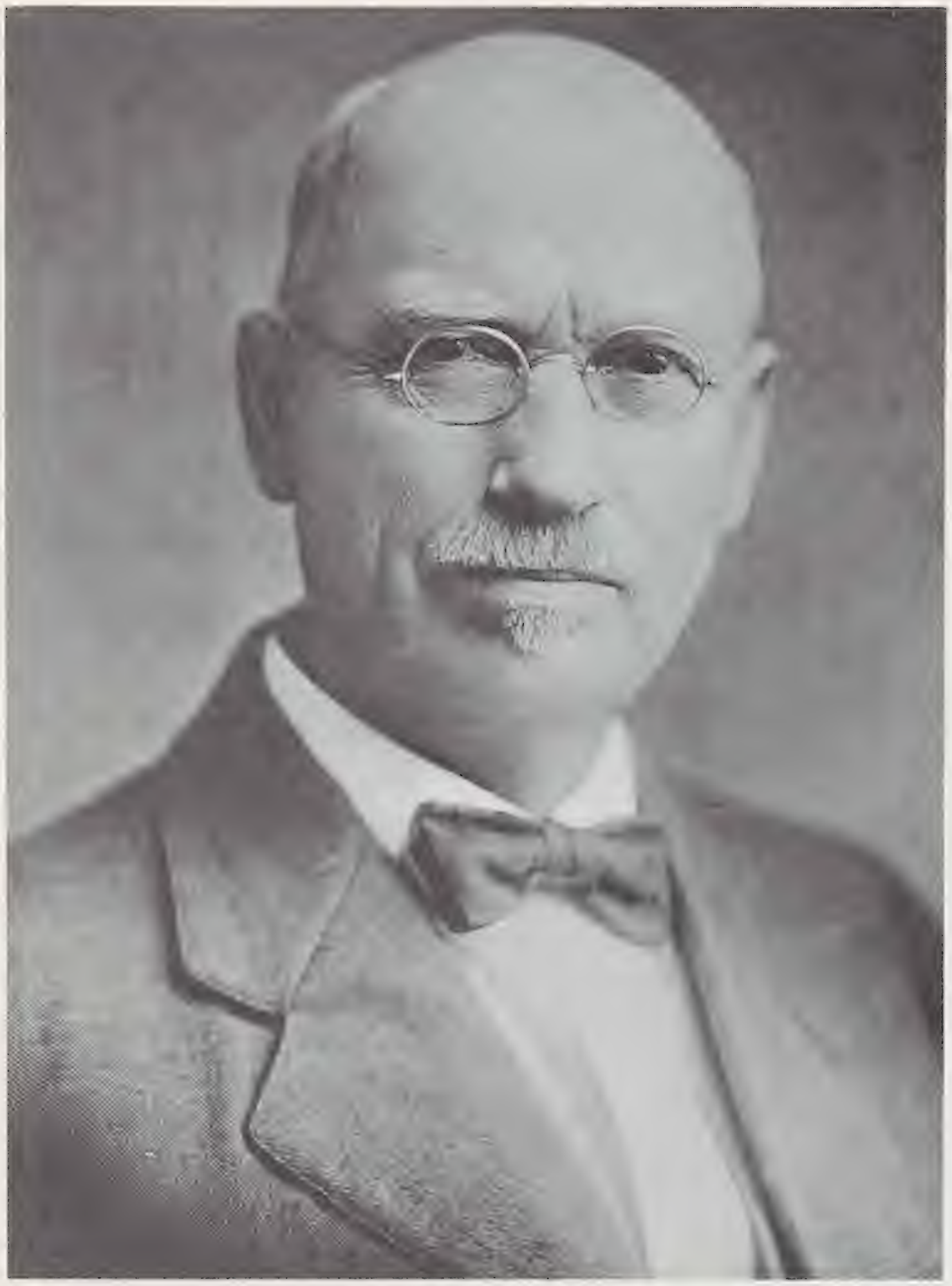
1-5. Hypotype (USNM 409097) from 17.8 m above the base of the section, 1, Side view showing wide carina and elongate neck, X 300; 2, Edge view showing spiralling carina, X 240; 3, Enlargement of carina showing struts, X 1080; 4, Apertural view showing spiralling carinae and radiate aperture, X 440; 5, Enlargement of radiate aperture, X 1400.

6-8. Hypotype (USNM 409098) from 2.4 m above the base of the section 6, side view X 280.

7. Apertural view of hypotype (USNM 409098) X 350.

8. Basal view of hypotype (USNM 409098) showing discontinuous spiralling carinae X 360.

PLATE 1



VIGNETTES OF COASTAL PLAIN GEOLOGY

JOHAN AUGUST UDDEN
1859-1932

Born in Sweden, Johan August Udden came to America at the age of two. Although primarily a teacher in his early years, he devoted a large amount of effort to the study of the geology of Iowa, Illinois, and, particularly, Texas. In 1911 he became a geologist for the Bureau of Economic Geology at the University of Texas and in 1915 was made its director, a post he held until his death. In addition to his landmark work in proving the value of well cuttings for subsurface geology, he also was the first to propose geophysical methods that would lead to the discovery of many gas and oil wells in the Gulf Coast. But his most lasting contribution may have been the discovery of the Big Lake oil field on land belonging to the University of Texas, which has added many millions of dollars to the University's endowment. (*From* C. L. Baker, 1933, Geological Society of America, Bulletin, v. 44)

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TULANE UNIVERSITY OF LOUISIANA
New Orleans

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PALEOECOLOGY OF *CREPIDULA* (MOLLUSCA:GASTROPODA) BEDS, JAMES CITY FORMATION (PLEISTOCENE), NORTH CAROLINA

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I. ABSTRACT

Masses of life-oriented valves of the marine gastropod *Crepidula fornicata* (Linne, 1758) form lenses in the James City Formation (Pleistocene) of North Carolina. The units are exposed along the banks of the Neuse River estuary in Craven County, near Johnson Point. Three other types of lithologic units, which occur in the bluffs at Johnson Point and differ (to various degrees) with respect to taxonomic composition and sedimentology, are *dense clay layers, shell-hash layers,* and *dispersed shell beds.* The primary distinguishing characteristics of the *Crepidula* beds include high shell/matrix ratio, high abundance of *C. fornicata,* and high relative proportion of epifaunal suspension feeders. The *Crepidula* beds may be classified as "minor simple shell beds" (terminology of Kidwell, 1982) produced through the biologic activity of epifaunal organisms.

Taxonomic analysis of the *Crepidula* beds shows them to contain over 30 species of Mollusca, which are predominantly small, vagrant, carnivorous and grazing gastropods, and infaunal, siphon-feeding pelecypods. The *Crepidula* bed communities were physically controlled communities whose compositions fluctuated in response to physical factors in the environment.

Populations of *C. fornicata* from different *Crepidula* beds show similar size-frequency distributions and survivorship curves. A high rate of mortality for juveniles is indicated, followed by lower, but consistently increasing mortality throughout adulthood. This pattern suggests that after the attainment of a threshold size, the onset of old age was the major determiner of mortality in the populations. Differences in size data between samples may be related to differences in environmental stability during the periods

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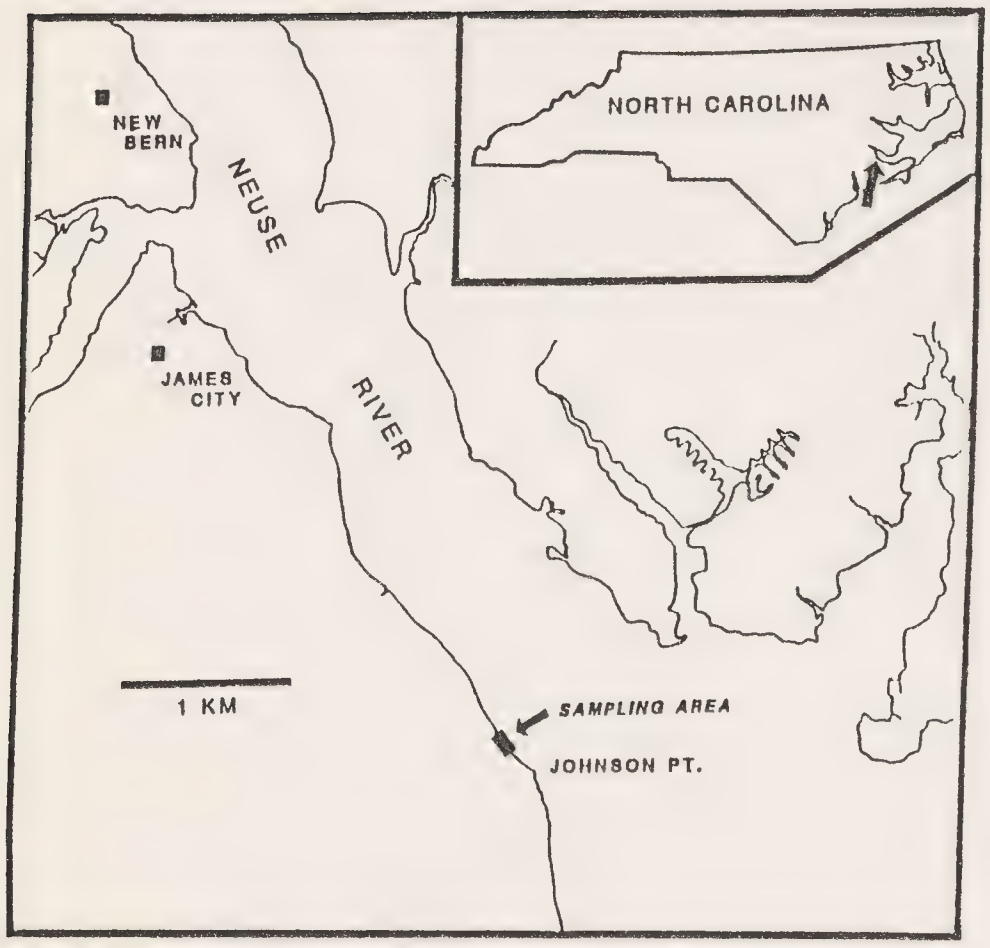

Figure 1. Locality map, Neuse River estuary of eastern North Carolina.

when the populations were living on the sea floor.

The *Crepidula* beds were deposited within a shallow, semi-restricted basin. The origin of the beds appears to be tied to the current regime and pattern of natural disturbances in the bay. Strong currents, produced through intermittent activation of tidal channels, initiated production of the units. Resurgence of *Crepidula fornicata* populations, in response to increased nutrients in the environment, resulted in the rapid accumulation of shell material. At the same time, a reduced rate of sedimentation abetted the proliferation of epifaunal species. Termination of *Crepidula* bed production in the James City Formation is attributable to changes in hydrography of the basin.

II. INTRODUCTION

The James City Formation (DuBar and Solliday, 1963) is the oldest stratigraphic unit recognized in outcrops along the Neuse River estuary, in Craven County of eastern North Carolina. Its deposits are exposed for approximately 6.5 km along the banks of the Neuse River, downstream from the town of New Bern (Fig. 1). Outcrops of the formation are in the extreme northwestern end and on the south bank of the estuary. The type locality is located 2.1 km downstream (east) from the town of James City (DuBar and Solliday, 1963), and strata containing dense *Crepidula* layers are a few kilometers farther downstream, in the vicinity of Johnson Point. The measured lateral extent of outcrop containing *Crepidula* layers at Johnson Point is approximately 150 m.

In the type area, the James City Formation is unconformably overlain by the Flanner Beach Formation and has a gentle regional dip to the southeast (Fig. 2). The base of the James City is not exposed in the type area, and the total thickness of the unit is uncertain; but it is not thought to exceed 15 m (DuBar, Solliday, and Howard, 1974).

The James City Formation is one of a series of coastal plain units that were depo-

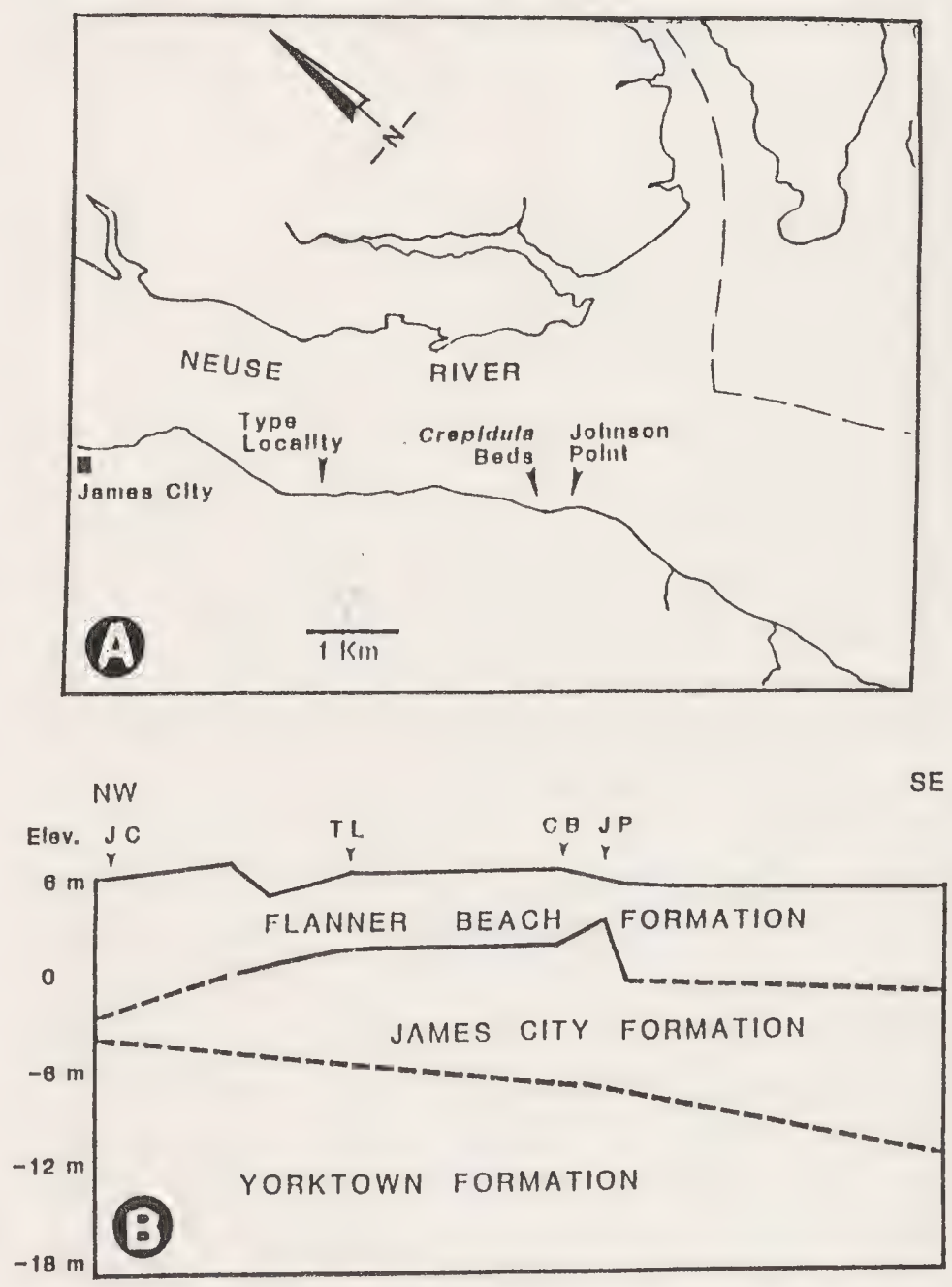

Figure 2. A. Locality map, Neuse River estuary. B. Generalized geologic cross-section of the study area (after DuBar, Solliday, and Howard, 1974). Arrows point to approximate locations, along a traverse from northwest to southeast, of the town of James City, JC; the James City type locality, TL; the James City *Crepidula* beds (sampling area), CB; and Johnson Point, JP.

sited during Pleistocene high-stands of sea level. Blackwelder (1981) estimated the age of the unit to be between 1.2 and 1.8 million years old; however, the results of more recent investigations into Atlantic Coastal Plain stratigraphy suggest a considerably younger age (0.7 - 1.3 million years) for the James City (Cronin *et al.*, 1984).

The *Crepidula* beds occur as discrete sedimentologic or biologic units, which are interbedded with three other types of lithologic units that show repeated and somewhat predictable patterns of occurrence in the outcrops. These other unit types are *dense clay layers, shell-hash layers* and *dispersed shell layers.*

The dense clay layers are usually 5 to 10 cm thick and consist of moderately indurated blue clay, with few scattered fossils. They occur both as thinner, discontinuous interbeds between *Crepidula* beds, and as thicker (*e.g.*, 0.4 m), more laterally extensive layers in the lower regions of some bluffs. The sparse fossil content of these units is mainly isolated single valves or small stacks (two or three individuals) of *Crepidula fornicata,* or valves of *Anadara aequicostata.* Sedimentary structures are generally absent, and trace fossils are limited to a few thin, sand-filled burrows that contain small pelecypod shells (*e.g.*, *Nuculana acuta)* and shell fragments.

The shell-hash layers tend to be irregular in shape, with a general thickness range of 10 to 20 cm. They are composed mainly of slightly indurated, silty mud and shell hash, and are situated at about the same stratigraphic level as the *Crepidula* beds (relative to the ground surface) or slightly lower. Their fossil contents are predominantly small specimens of *Mulinia lateralis* and *Nuculana acuta,* with relatively few broken and disarticulated adult specimens of *Anadara aequicostata* and *Crepidula fornicata.* The shell-hash layers contain the most sand of any of the lithologic units and probably were deposited under turbulent conditions.

The *Crepidula* beds are discontinuous, vertically repeating, in some places interfingering shell beds, approximately 7.5 to 12 cm thick, and situated below the more continuous dispersed shell layers. They are composed mainly of large (*e.g.*, 6 to 12 individuals in a stack), densely packed stacks of *Crepidula fornicata* (Fig. 3) in slightly indurated, silty mud matrix, in which there are also a few sand-filled burrows. The stacks appear to be randomly oriented and most are rotated out of life positions. *Crepidula* shells are bored and encrusted to varying degrees, but most are fairly well-preserved. Most other fossils in these units are epifaunal species.

The dispersed shell beds range in thickness from 0.4 to 0.75 m and occupy the highest stratigraphic positions in the bluffs of the four unit types (immediately below the soil and root zone). The faunas of these units are generally more diverse than those of the *Crepidula* beds, but not as diverse as those of the shell-hash layers. The orientation of shells within the dispersed shell beds indicates a depositional setting of relatively low turbulence. Large clams and oysters, and small stacks (four or fewer individuals) of *C. fornicata* remain articulated and are often *in situ.* The matrix is grey-brown, moderately indurated, clayey mud. Sand-filled burrows of the sort found in the dense clay layers and *Crepidula* beds were not observed in the dispersed shell layers.

III. METHODS

Samples were collected during two trips to the field area. The first trip was essentially a reconnaissance expedition surveying faunal content and sedimentology of shell beds along the 150 m extent of outcrop containing *Crepidula* beds. Twelve six-liter bulk samples were collected, and at each sampling station notes were recorded regarding shell density, preservation, dispersion, orientation, relative abundance of epi-bionts, and approximate size and number of individuals in *Crepidula* stacks. These samples were useful for establishing the general faunal and sedimentologic compositions of the different shell bed types, but represented too great a span of time to be useful in detailed analysis of preserved community attributes of the assemblages. During the second trip, samples were collected from three well-preserved *Crepidula* beds that would allow for higher resolution analysis of faunal content and size-frequency distribution of *C. fornicata* within those units.

Figure 3. A. Densely-packed *Crepidula* stacks and silty mud matrix of a James City *Crepidula* bed. (Scale divisions are 5.0 cm) B. Faunal assemblage of a dispersed shell bed.

The fossil material was sorted and counted at the Tulane Geology Department. Faunal lists, including the number of specimens in each listing (absolute abundance) were compiled for each sample. This information has since been published by Miller and DuBar (1988) and Miller (this volume) and will not be repeated here. Size-frequency data for *C. fornicata* were obtained by measuring all specimens found in each of the three higher resolution samples.

Gross separation of sand-, silt- and clay-sized material in sediment samples was accomplished through modified sieving and decantation procedures of Folk (1965, pp. 18-24, and p. 40) and Blatt (1982, p. 520). Percent calcium carbonate in the samples was determined by weighing before and after digestion in dilute hydrochloric acid.

All but two of the survey samples were composed predominantly of very fine-grained material with the average proportion of silt and clay being about 55% for the 12 samples. The sand-sized material was mainly medium to fine-grained, subangular quartz and calcium carbonate shell fragments. X-ray diffraction analysis of the James City clay minerals by DuBar, Solliday, and Howard (1974) showed them to be predominantly mixed-layer illite-montmorillonite, with minor amounts of kaolinite. The relatively high proportion of coarser-grained material in the shell-hash samples is probably indicative of a higher energy depositional environment. The higher resolution *Crepidula* bed samples were less variable than the survey samples, and averaged 30.5% sand-sized, 42.9% clay-sized, and 25.7% clay-sized material.

The biolithic content of sediments reflects "dead shell" abundance on the sea floor, which influences such community attributes as number and diversity of epifaunal species (see Driscoll and Brandon, 1973), and may indicate the ancient community's residence time in the environment. The survey sediment samples ranged from 13% to over 30% calcium carbonate. Analysis of sediment (material less than approximately 1 mm in diameter) from the *Crepidula* bed samples showed substantially less calcium carbonate (between 7 and 11%), the bulk of which was contained in the coarsest size fractions.

IV. BIOLOGY OF *CREPIDULA FORNICATA*

Crepidula Lamarck (Gastropoda:Calyptraeidae) is a genus of marine Mesogastropoda found in modern shallow-water environments. Hoagland (1977) states that this genus dominates many marine communities in both biomass and energy cycling, relative to other filter-feeding organisms present. There are 40 valid species known worldwide, ten of which are extinct (Hoagland, 1977).

Feeding in *Crepidula fornicata,* a prosobranch mesogastropod, is by filtering particulate food matter (in the form of marine plankton) from the sea water. Loomis and Van Nieuwenhuyze (1985) observed a feeding behavior in *C. fornicata* that they suspect may enhance its chances for survival under conditions of low current velocity and high turbidity. Postural changes of snails in direct contact with muddy sediments allowed them to resuspend particulate matter and then filter it from the water. Filter-feeding efficiency in *C. fornicata* decreases under conditions of high turbidity (Johnson, 1971), but Loomis and Van Nieuwenhuyze feel that the ability to feed at all under circumstances that would clog the filtering apparatus of most other filter feeders is a selective advantage.

Adults of the species are sedentary and normally found in stacks composed of twelve or more individuals (Fig. 4), in which females are situated toward the bottom and the younger males toward the top. The following is a summary of proposed functions of the stack in *C. fornicata.*

1. It allows for formation of a breeding unit. Thus, stacking insures the availability of one or more suitable breeding partners. In addition, it minimizes the threat of predation on motile males who would otherwise be required to wander in search of the sedentary females (Hoagland, 1979).
2. It allows for production of feeding currents. By alignment of the right anterior shell margins of members within the stack, the inhalent water current entering the mantle cavity is maximized. At the same time, the excurrent flow of feces and pseudofeces

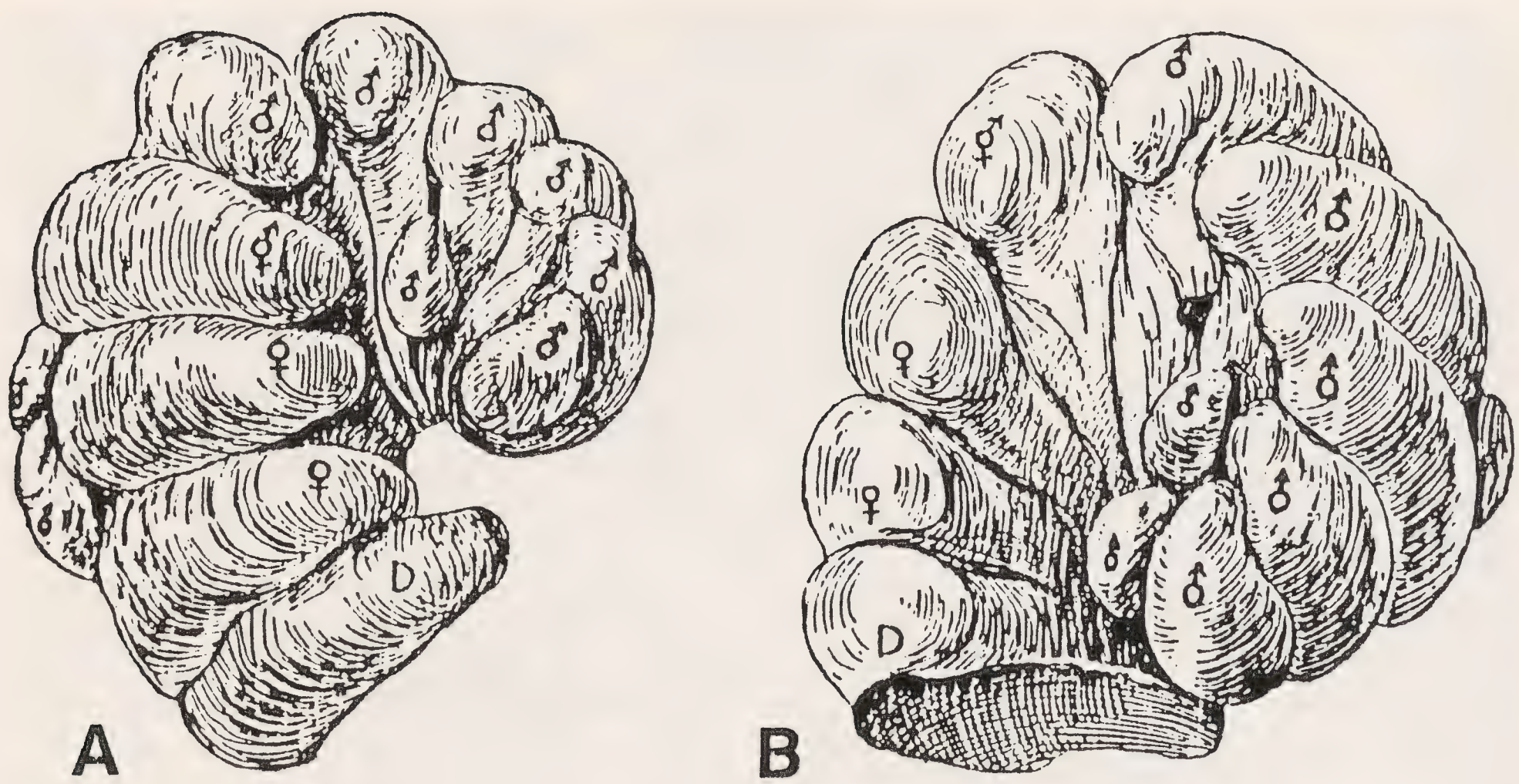

Figure 4. Two views (A and B) of a large *Crepidula* stack, consisting of one (dead) supporting shell (D), two females, one transitional individual, six non-motile males and three motile (supplementary) males. (From Coe, 1936)

is augmented by subtle changes in stack shape (Hoagland, 1979).

3. It provides suitable substrate for settling larvae. The preferred substrate of *C. fornicata* is a smooth, convex surface (Hoagland, 1978, 1979). This shape exposes individuals to greater currents and less sedimentation than either flat or concave surfaces. Stacking offers unlimited substrate of this type for new members of the population.

Members of the family Calyptraeidae exhibit protandry: a complicated form of hermaphroditism in which the young individuals always develop first into functional males, progress through a intermediate phase, and later mature into functional females. *Crepidula fornicata* and other species within this genus differ from the rest of the family in that the change from male to female does not occur at the same time (age) for all individuals. Instead, the length of time spent in each sexual phase is governed by specific factors in the individual's immediate environment (Purchon, 1977). Many studies (*e.g.*, Coe, 1936, 1938a and b, 1942; Hoagland, 1979) have been aimed at determining the nature of factors responsible for change of sex in *Crepidula fornicata*. In general, the type and length of association of an individual with other members of the population appears to be the most important controlling factor.

Recruitment effort in populations of *C. fornicata* appears to be intrinsically related to their residence time in the environment. Total egg output per adult tends to decrease as the density of the population increases (Hoagland, 1978). This is because a larger proportion of each individual's lifetime is spent in the male phase for non-colonizing populations.

Growth and variability in *Crepidula fornicata* are mediated by conditions in the environment, and by the life history of the individual. Growth rate is higher in isolated males than in mated males, and is most rapid during the intermediate stage occurring between the male and female phases. Widely deviating growth forms are seen in nature, including large and dwarfed individuals, and variability in shape, color, and texture. Two basic shell morphologies are commonly exhibited (Coe, 1942). The first is a narrow growth form, found on muddy or sandy substrates. It results from surface limitation for foot attachment, imposed by the stacking behavior. Shells of this type are smooth, narrow and highly arched (Fig. 5A), and usu-

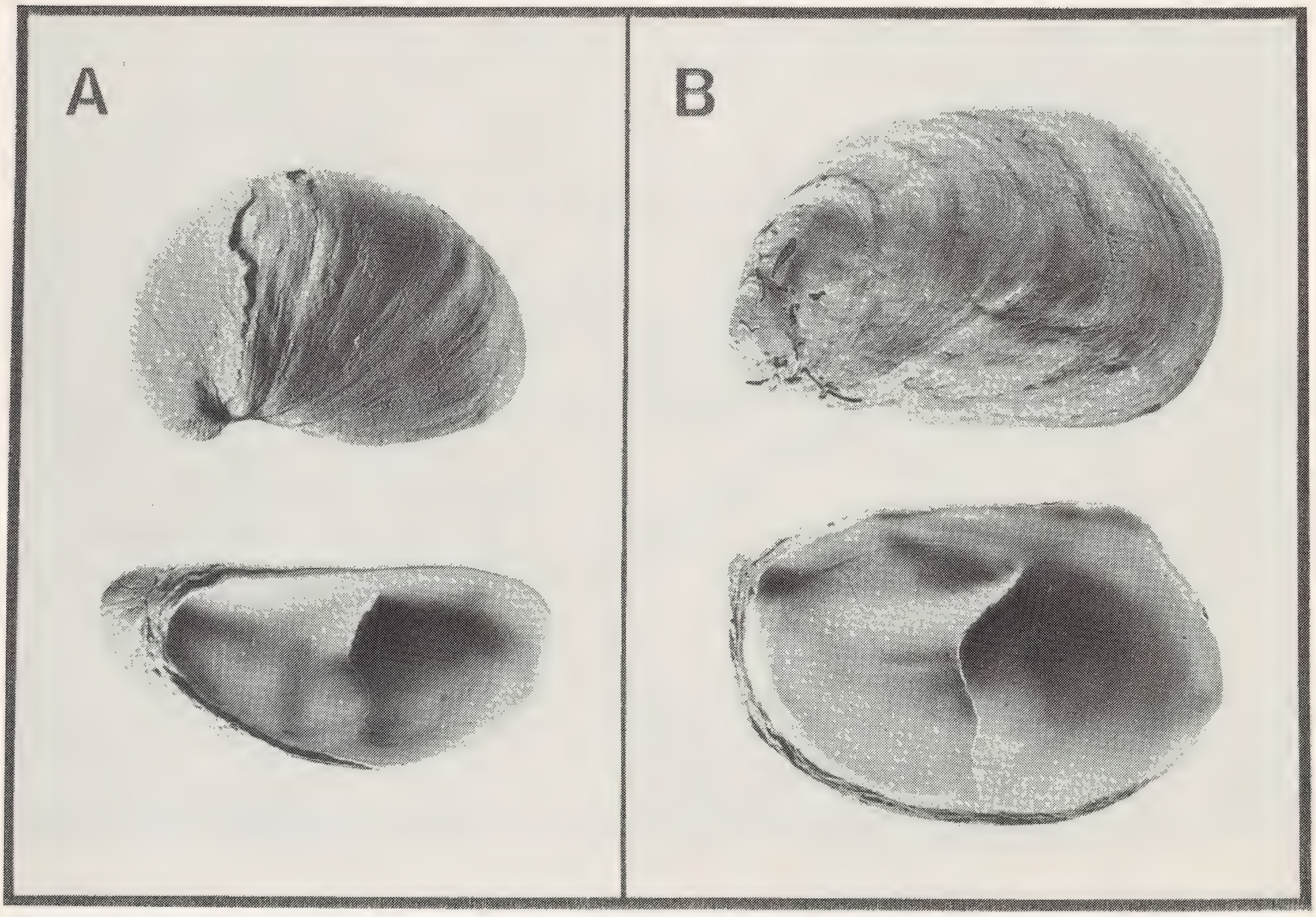

Figure 5. Growth forms in specimens of *Crepidula fornicata* from the James City *Crepidula* beds. The narrow form (A) resulted from limited growth surface (within a stack). The broad, flat form (B) was attained through growth on an unrestricted surface.

ally occur in large stacks of as many as sixteen individuals. The second growth form is a flat, oval shell (Fig. 5B), which may be found singly or in small groups of two or three individuals. In this case, substrate is an unrestricted surface upon which maximum shell size may be attained. If a young or half-grown individual is transferred from a convex surface to one that is flat, the narrow growth form can be halted and replaced by broad, flat shell growth. Coe (1942) noted that sex transformation usually accompanied the onset of a new growth form in experiments of this nature. Young individuals that attach themselves to very small pebbles or shells develop into highly arched dwarfs. Other highly variable shell shapes are produced by growth on irregular surfaces. For instance, if an individual attaches itself to the shell of a scallop, the crenulated surface will be reflected in the texture of the snail's shell as it grows (Hoagland, 1977).

Figures 5 and 6 show some of the various shell shapes observed in specimens of *C. fornicata* from the James City *Crepidula* layers. The highly arched shell form (Fig. 5A) predominated in the collections, which is understandable, because most of the individuals occupied positions in stacks. Irregular shapes (Fig. 6d and e) were also common in the samples. Constrictions on some shells (Fig. 6a, b, and c), which indicate a change in growth form (from narrow to broad) during the life of the individual, have been called "mate marks" (Hoagland, 1977). They are usually caused by a change in substrate from a more restricted surface (*i.e.*, the shell of a female), to a less restricted surface, which probably coincided with sex transformation (Coe, 1942; Hoagland, 1977).

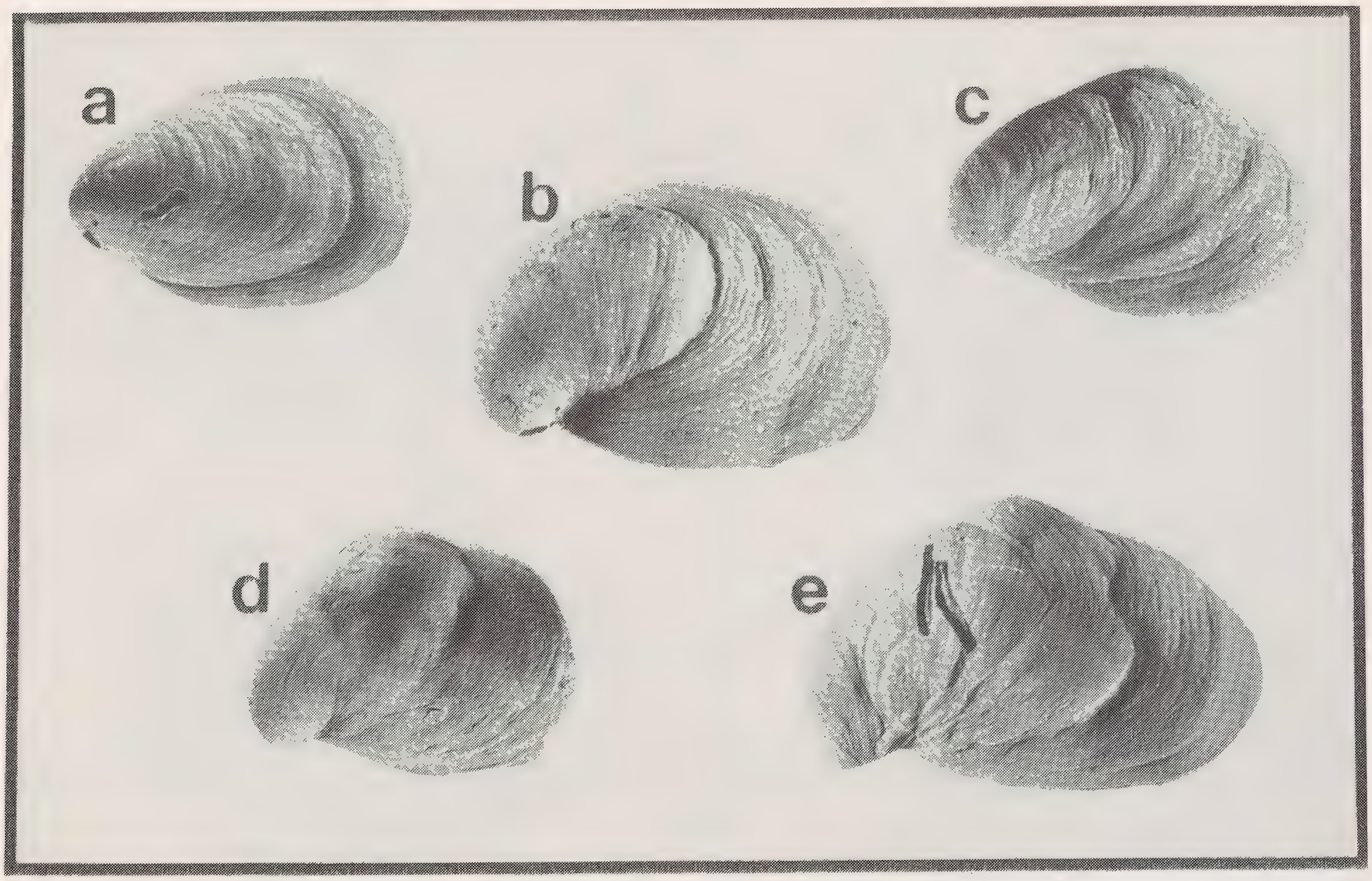

Figure 6. Morphologic variability in specimens of *Crepidula fornicata* from the James City *Crepidula* beds. "Mate marks" (a, b and c) indicate a change in growth surface from more to less restricted; irregular shell growth (d and e) is due to uneven growth surfaces.

V. PALEOSYNECOLOGY OF *CREPIDULA* BEDS

Crepidula fornicata is a common faunal element in outcrops of the James City Formation along the northwest bank of the Neuse River estuary. It is prevalent in the other types of shell beds, as well as in the *Crepidula* beds upon which this study is focused. For this reason, it may be useful to outline specific attributes of "*Crepidula* Beds" that distinguish them from the other fossiliferous units at Johnson Point.

The most obvious features of the James City Crepidula beds (Fig. 7) are:

(1) high density of shells (high shell/matrix ratio);
(2) numerical abundance of *Crepidula fornicata;*
(3) highly visible as discrete layers, particularly when viewed from a distance; and
(4) evidence of post-depositional disturbance generally limited to reorientation of stacks, with fossils mainly whole and well preserved and *Crepidula* stacks not disaggregated.

Secondary features that can be recognized in conjunction with, or directly resulting from the primary features include:

(1) relatively fewer specimens of *Anadara aequicostata,* or other infaunal bivalves *(e.g., Mulinia lateralis* and *Nuculana acuta);*
(2) common occurrence of epifaunal and encrusting species *(e.g., Balanus* sp. and *Ostrea sculpturata);*
(3) larger stacks of *C. fornicata* (usually more than 6 individuals); and
(4) lower stratigraphic position in the bluffs than the less compact, quiet water assemblages.

The James City *Crepidula* beds fit the criteria of Kidwell (1982) for being classified as "minor simple shell beds." Attributes that describe this general class of shelly accumulation are: (1) relatively thin (cm to 10's of cm); (2) contained within the

Figure 7. Characteristics of *Crepidula* beds: composed mainly of densely-packed, aggregated stacks of *C. fornicata* in slightly disturbed orientations (A); form discrete layers in the bluffs B).

bounds of a single facies; (3) geometry ranging from irregular pods and layers of pods, to single valve stringers and thicker beds; (4) usually lacking lateral or vertical variation in composition or taphonomic character of fossil assemblages and sedimentary matrices; (5) may or may not be associated with depositional discontinuities; and (6) relatively simple taphonomic histories. Kidwell defines "minor simple shell beds" as generally short-term events resulting from biologic and physical processes capable of concentrating shells over a period of time that may range from months to tens of years, or the portion of the absolute time scale designated "ecologic time" (see Kidwell, 1982, text-fig. 1).

The *Crepidula* beds at Johnson Point range from 7.5 to 12.0 cm in thickness, and individual beds can not be traced laterally for more than a few meters. All beds are contained within the lateral bounds of a massive mudstone unit, and tend to vary slightly in taxonomic and sediment matrix composition. The beds exhibit a roughly lensoidal geometry, being slightly thicker towards the middle of the layers and tapering at the outer edges.

Fossil preservation within the layers is mainly related to only two factors: length of exposure on the sea bottom, prior to being buried; and post-burial oxidation and erosion due to groundwater infiltration. Some indicators of longer residence times on the sea bottom include higher incidence of encrusted, bored and fragmented shells and possibly, local hardground development. Assemblages that existed for relatively short periods of time before being buried are more likely to contain "clean" whole shells. In regard to the effects of groundwater, whether or not a layer has been altered appears to depend upon its proximity to the overlying soil layer. Shell beds situated near the bottoms of bluffs have been generally spared chemical alteration by migrating fluids. Those nearer the tops of bluffs have sustained more oxidation and post-depositional erosion.

Biogenic reworking of the sediment by infaunal organisms is apparent from the absence of bedding within or between the units, and some within-habitat disturbance is evident. However, there is no evidence of large-scale transport processes, therefore the bulk of the fossil material is probably indigenous. The *Crepidula* beds are not associated with unconformities at either their upper or lower bed contacts and have the appearance of simply "floating" in the outcrops.

Community Structure of Crepidula *beds*

The James City *Crepidula* beds are composed predominantly of molluscan species, but also contain species of Crustacea, Bryozoa, Annelida, Porifera and Cnidaria (see Miller, this volume). Table 1 lists the niche characteristics of molluscs from the units.

Specimens of *Crepidula fornicata,* a sessile, epifaunal suspension feeder, composed the bulk of the shell material in samples from the beds. With the exception of *Crepidula plana,* the remainder of the gastropods were small, vagrant carnivores, grazers and parasites (see Table 1). *Boonea seminuda,* an ectoparasite that lives on *C. fornicata,* was numerically abundant in the samples. *Anachis lafresnayi* and *A. obesa,* two carnivorous species, were also recovered in large numbers.

Pelecypods found in the units were predominantly infaunal siphon feeders. The most common burrowing species were *Nuculana acuta* and *Mulinia lateralis.* More significant in terms of actual biovolume, however, were *Anadara aequicostata* and *Ostrea sculpturata,* two epifaunal suspension feeders. Rapid burrowers *(e.g., Tellina texana* and *Ensis directus)* were scarce and commonly fragmented in the samples.

Johnson wrote (1972, p. 151):

> The environment of benthic communities on clastic substrate is usually gradational. Muds grade into muddy sands and these, in turn, into sands. Depth, light, salinity and water motion tend to vary in a continuous fashion. As a consequence, benthic communities on clastic substrates tend to be continuous and intergrading, both in shallow and deep water.

The James City *Crepidula* beds are typical of Johnson's (1972) benthic com-

TABLE 1. Niche Characteristics of Molluscan species from the James City *Crepidula* Beds. Key: SF, Suspension Feeder; DF, Deposit Feeder; C, Carnivore; G, Grazer; EP, Ectoparasite; SC, Scavenger; SI, Siphon Feeder; E, Epifaunal; I, Infaunal. (Information is from Stanley, 1968, 1970; and Driscoll and Brandon, 1973.)

Taxa	Feeding Mode	Substrate Relationship	Locomotion-Attachment
Gastropoda			
Crepidula fornicata	SF	E	Foot attached
Crepidula plana	SF	E	Foot attached
Boonea seminuda	EP	E	Vagrant
Anachis lafresnayi	C	E	Vagrant
Anachis obesa	C	E	Vagrant
Nassarius albus	SC	E	Vagrant
Nassarius consensus	SC	E	Vagrant
Natica pusilla	C	E	Vagrant
Urosalpinx cinera	C	E	Vagrant
Eupleura sulcidentata	C	E	Vagrant
Fasciolaria lilium	C	E	Vagrant
Turbonilla sp.	EP	E	Vagrant
Melanella sp.	EP	E	Vagrant?
Marginella (Prunum) sp.	C	E	Vagrant
Busycon canaliculatum	C	E	Vagrant
Seila adamsi	G	E	Vagrant
Epitonium humphreysi	C	E	Vagrant
Pelecypoda			
Anadara aequicostata	SF	E	Slow Burrower*
Nuculana acuta	DF	I	Active Burrower
Nucula proxima	DF	I	Active Burrower
Mercenaria campechiensis	SI	I	Shallow Burrower
Mulinia lateralis	SI	I	Burrower
Ostrea sculpturata	SF	E	Cemented
Argopecten irradians	SF	E	Nektic, Recliner
Tellina texana	SI	I	Rapid Burrower
Corbula conradi	SI	I	Slow Burrower
Chione cancellata	SI	I	Burrower
Yoldia limatula	DF	I	Active Burrower
Ensitellops protexta	SI	I	Burrower
Ensis directus	SI	I	Rapid Burrower
Polyplacophora	SC	E	Vagrant
Chaetopleura apiculata	G	E	Vagrant

*occasional byssal attachment

munities on clastic substrates, in that their faunal compositions reflect the gradational nature of the environment. Three types of species that occur in the beds are (see Johnson, 1972, p. 157): (1) characteristic species - the most obvious faunal elements, which tend to occur in the greatest numbers; (2) intergrading species - those species characteristic of another, usually adjacent environment; and (3) ubiquitous species - species that occur in several settings, but are not characteristic of any one environment. *Crepidula fornicata* is the obvious characteristic species of the *Crepidula* beds. It dominates the faunas both numerically and in bulk volume. *Boonea seminuda* which lives specifically in association with *C. fornicata,* is also prevalent,

and can be classified as a secondary characteristic species of the *Crepidula* bed communities. Most of the pelecypod taxa found in the units are considered to be intergrading species, associated with either higher or lower energy environments than what is optimal for *Crepidula* bed formation. Species thought to be intergradational toward a typically higher energy environment include rapid burrowers such as *Tellina texana, Ensis directus,* and *Yoldia limatula.* An intergrading species leaning toward the lower-energy end of the environmental gradient is *Ostrea sculpturata. Anadara aequicostata* and *Mulinia lateralis* can be considered ubiquitous species, since they are common in units suggestive of quiet water deposition (i.e., dispersed shell beds), as well as in the higher energy shell-hash and *Crepidula* layers.

The James City *Crepidula* beds are thought to represent low grade communities whose occurrence and compositions were under the direct influence of the physical environment (see Margalef, 1968; Johnson, 1972). Regular fluctuations in certain key parameters in the environment (discussed in subsequent sections) resulted in density variability of the characteristic species *(Crepidula fornicata)* over time.

Spatial Distribution Within C. fornicata *Populations*

Three types of spatial distribution that can occur within populations are random, regular or overdispersed, and clumped or underdispersed (Dodd and Stanton, 1981). As evidenced by the preserved stacks of the James City *Crepidula* beds, individuals within the *C. fornicata* populations were underdispersed or spatially clumped during life; but a further question with respect to scale should be considered. Clumps of a given species may occur in an area, but the clumps themselves may be randomly distributed (Dodd and Stanton, 1981). The question of whether the situation in the James City *Crepidula* beds was one of randomly spaced clumps (stacks), or one of stack clustering is pertinent to a complete understanding of the population structure, and a reasonable interpretation of the origin of the beds. A primary distinguishing feature of the *Crepidula* layers (with respect to the other types of shell beds in the James City Formation) is the manner in which large stacks are closely packed together. It appears likely that the stacks composing the original *Crepidula* populations were also underdispersed on the substrate, and that the discontinuous, roughly lensoidal beds represent original patches of sea floor that contained many clustered stacks. Inhomogeneities in the distribution of suitable habitat, and positive interaction between individuals of the species are proposed reasons for clumping in populations (Dodd and Stanton, 1981). Biological evidence suggests that these two factors are interrelated in populations of *Crepidula fornicata.* In regard to substrate preference of settling spat, Hoagland (1978) found that the newly metamorphosed young are attracted to adults and juveniles of their own species, and particularly to females. Under laboratory conditions, substrates with adult snails received more than three times the number of spat of substrates without adults. Apparently, the presence of adults increases the likelihood of young settling on the same substrate in nature as well, but the influence is simply a presence or absence effect. No relationship between density of adults and density of settling spat has been indicated (Hoagland, 1978).

Biological means by which clumped populations may be produced are: postponement of larval metamorphosis until a suitable substrate is found; survival of only those larvae that settle within the clumps; concentration of food supply in only certain areas; and development of the young from eggs deposited near the parent (Dodd and Stanton, 1981). Food supply and larval settling behavior are thought to have been the major determiners of dispersal in the *Crepidula* beds. Live and/or dead individuals can also be physically concentrated in an area through the action of strong currents, but this is not thought to have had a significant influence in the *Crepidula* beds.

Age and Size Distribution of Population Members

Rates and patterns of mortality in populations of *Crepidula fornicata* were assessed through analysis of size-frequency data from three *Crepidula* bed samples.

The lengths of specimens of *C. fornicata* in the samples ranged from less than 2 mm to about 42 mm. Although the numbers of individuals in the three samples varied greatly, the tendency toward large numbers of small specimens was exhibited in each case (Fig. 8). In all three samples more than half of the individuals were less than 10 mm long. Sample 1, however, contained appreciably fewer specimens of the smallest size categories than the other two samples. No shells of *C. fornicata* less than 2 mm in length were recovered, and only about 1% of the total number of individuals in that sample fell into the 2-4 mm category, compared to 22% for samples 2 and 3.

Sample 1 had the largest mean specimen size of the three groups (probably due to the relative absence of individuals in the first two size categories), and sample 2 had the smallest (see Fig. 8).

Size-frequency curves for the three samples were constructed in the manner prescribed by Folk (1965, p. 43). The size-frequency data for the three groups were converted into cumulative curves. Then, slopes of tangents to the cumulative curves were plotted at 1 mm intervals. Size-frequency curves enables distribution to be more readily observed and interpreted, by illustrating overall trends (modes) in the populations.

The curves for the sampled *Crepidula* populations are strongly right (positive) skewed (see Fig. 9). Large, well-defined peaks occur at about 5 mm for all three populations. Less conspicuous inflections appear at approximately 31 mm in samples 2 and 3, and at 34 mm in sample 1. It is rare for assemblages to show more than one or a few strong peaks in their size frequency curves, and polymodality in sufficiently large samples has been related to successive annual broods in populations (see Craig and Hallam, 1963). The peaks occurring at 31 and 34 mm in the *Crepidula* populations probably represent mortality

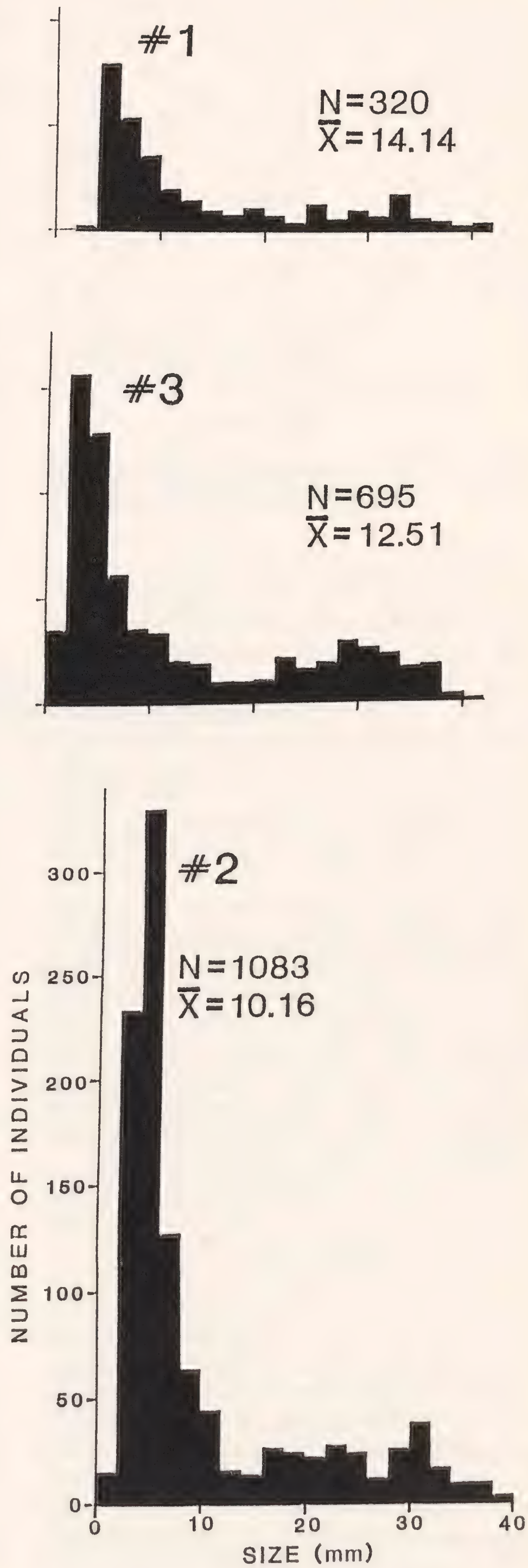

Figure 8. Size-frequency data for specimens of *C. fornicata* from *Crepidula* bed samples 1, 2 and 3. N is the number of specimens measured in each sample. $\bar{x}$ is the mean size for specimens in each sample. Scale is the same for all three histograms.

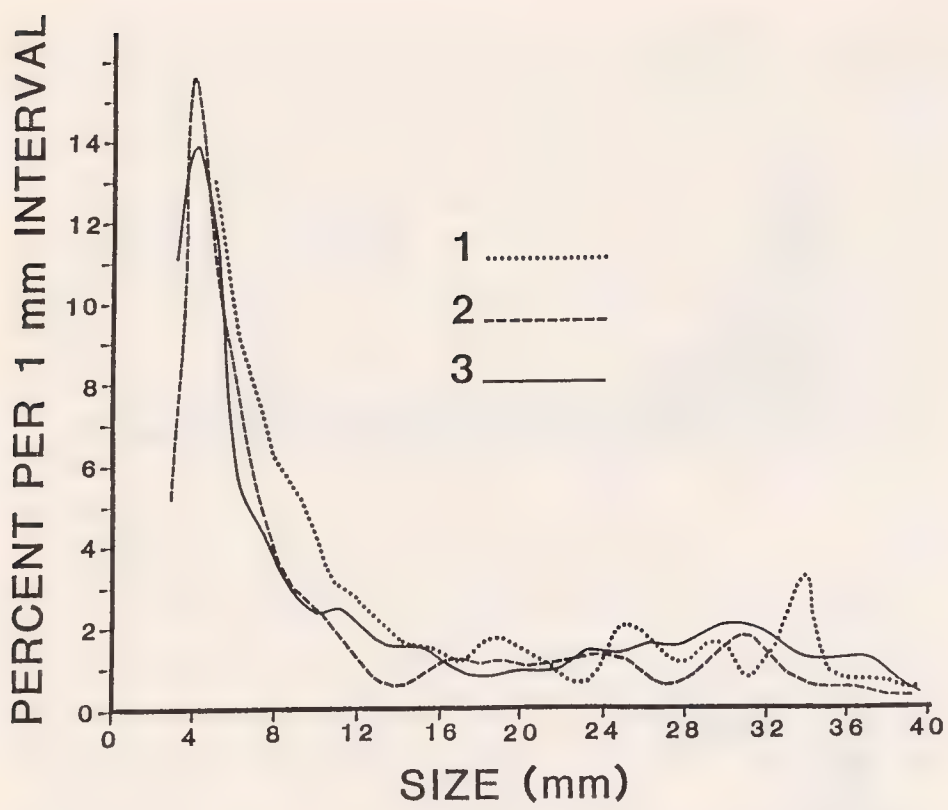

Figure 9. Size-frequency curves for *C. fornicata* in *Crepidula* bed samples 1, 2 and 3.

in an older generation of snails (*i.e.*, one or more seasons) than the individuals represented by the large spikes at 5 mm. The other small, irregular inflections in the curves (particularly in sample 1) may be spurious, or the result of size variability within the species. In addition to mortality rates, size-frequency distributions are dependent upon growth, so it is understandable that data for populations of *C. fornicata* might produce relatively complex curves. The fossil populations, although extremely short-term geologically, are thought to represent recruitment and natural mortality in *C. fornicata* populations over a period of time (*i.e.*, years), rather than mass-kill censusing (see Hallam, 1972; Dodd and Stanton, 1981). The general trend illustrated is for a high rate of mortality in the infant sizes, more or less constant mortality throughout youth and adulthood, and a renewed high rate of mortality in old age.

Survivorship curves (Figs. 10B, 11B and 12B) were plotted by the method prescribed by Hallam (1972). The number of survivors is expressed as percent of the total population sampled, and is plotted on a logarithmic scale along the ordinate. Length from the size-frequency histograms (Fig. 8) was converted to relative age, and plotted along the abscissa. Relative age was determined from size by assuming that the largest individuals in the three samples (42 mm) were the oldest. This size was then designated maximum age for members of all three populations. All other sizes are expressed as percentages of the maximum age. This technique is somewhat problematic for stacked populations of *C. fornicata,* because shell length only roughly correlates to true body mass in the highly arched growth form. Also, older individuals in the population can be much smaller than younger individuals, depending upon stack constraints (*e.g.*, a small basal shell) (Hoagland, written comm.).

Specific patterns of mortality in populations are enhanced in survivorship curves. Mortality rate is indicated by slope. Changes in slope along the length of the curve reflect the mortality patterns in the populations. Three basic curve shapes may occur (MacArthur and Connell, 1966; Hallam, 1972): (1) convex to the upper right, signifying increasing mortality with age; (2) approximately linear, reflecting constant mortality; and (3) concave to the upper right, indicating decreasing mortality with age. Survivorship curves for species living on firm substrates and/or in environments that are relatively turbulent are characteristically convex (Richards and Bambach, 1975). Apparently, once individuals in those settings have survived long enough to begin producing calcified shells, the predominant factor that will ultimately affect survival of their size class is the onset of old age. On the other hand, species in muddy environments typically suffer extremely high juvenile mortality due to predation and difficulties in feeding, breathing, and maintaining position on the muddy substrate. These groups characteristically have concave survivorship curves, and the decrease in mortality rate corresponds to attainment of size capable of maintaining a stable position on the sea floor.

The survivorship curves for the three *Crepidula fornicata* populations are more complex than the general cases described above (see Figs. 10B, 11B and 12B). They are linear to weakly concave up to about 30% of the maximum age, then become convex through the remainder of the age classes. Sample 2, in particular, exhibits an extremely high rate of mortality in the youngest age classes (Fig. 11B). This may reflect particularly harsh environmental conditions for that population during the time of spatfall (see Richards and Bambach, 1975). It appears that up to a point (a

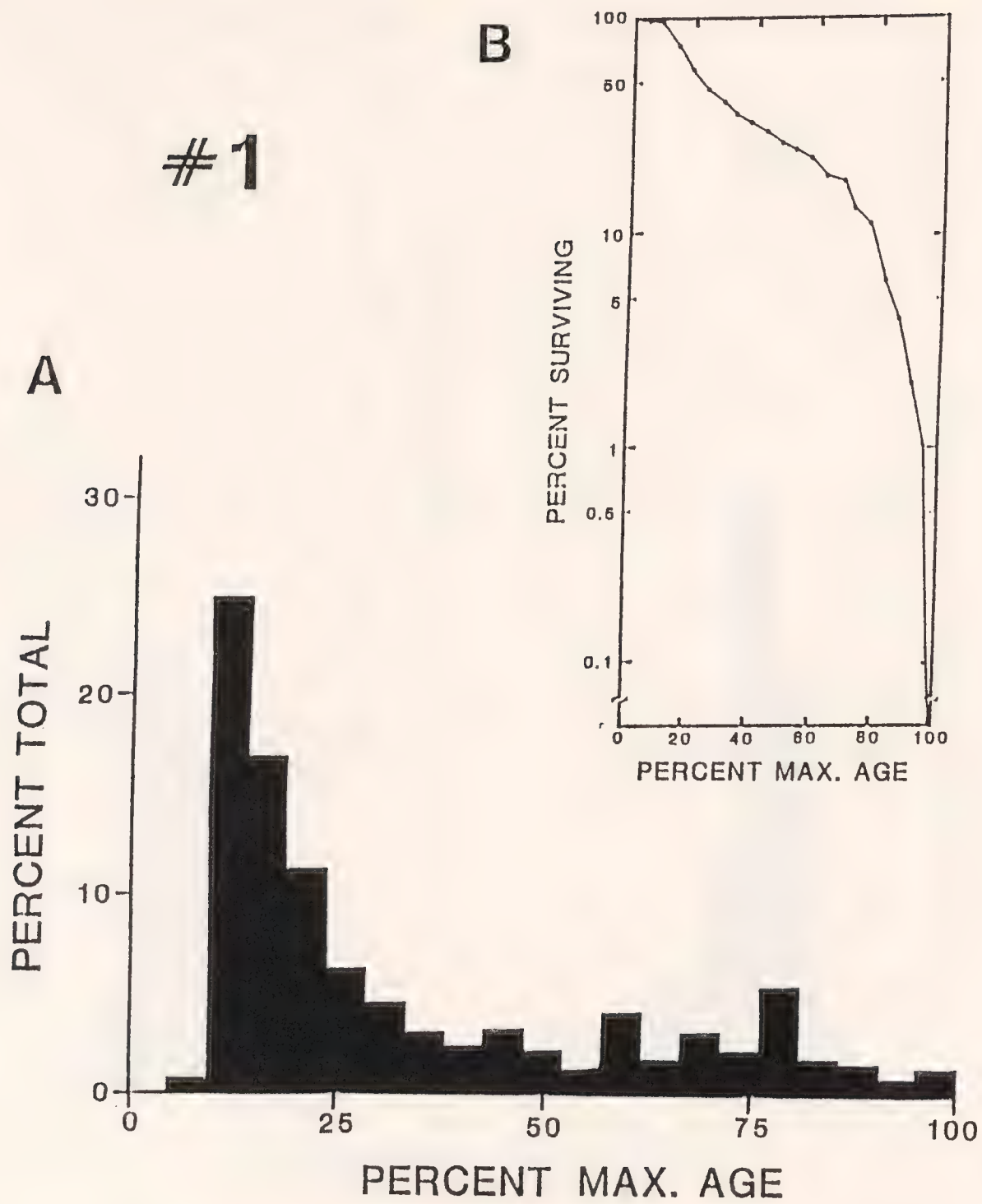

Figure 10. Age-frequency histogram (A), and survivorship curve (B) for *C. fornicata* in *Crepidula* bed sample 1.

threshold size), smaller individuals in the *Crepidula* populations tended to experience higher mortality than larger individuals. The threshold size, which is approximately 14 mm in the sampled populations, may correspond to the end of the motile male phase, during which individuals were more susceptible to predation. After reaching sedentary adulthood, gerontic factors took over as the main influences on death or survival. Since growth in *C. fornicata,* as in many molluscan species, continues throughout the lifetime of the organism (albeit, more slowly after attaining maturity), individuals over the threshold age (size) had a progressively higher chance of dying.

The survivorship curves for the three *Crepidula* populations, although similar in overall shape, vary somewhat with respect to (apparent) ages at which specific changes in slope occur. In particular, smaller sizes at points of change in mortality are indicated by the curve for sample 2 (see Fig. 13). An overall smaller size of individuals is characteristic of *Crepidula* populations that are new settlements or colonizing populations. Sex change in such populations tends to occur at a smaller size and younger age, due to a lower proportion of females (Hoagland, 1978). Growth rate is reduced following sexual maturity in *C. fornicata* (Hoagland, 1978), so the curve for sample 2 may also record a drastically reduced rate of growth.

VI. DISCUSSION

Depositional Setting

Based on sedimentologic and faunal (molluscan and foraminiferal) data, DuBar, Solliday, and Howard (1974) interpreted the depositional environment of the James City Formation as having been a shallow, semi-restricted embayment. The generalized faunal and sedimentologic data produced by the reconnaissance sam-

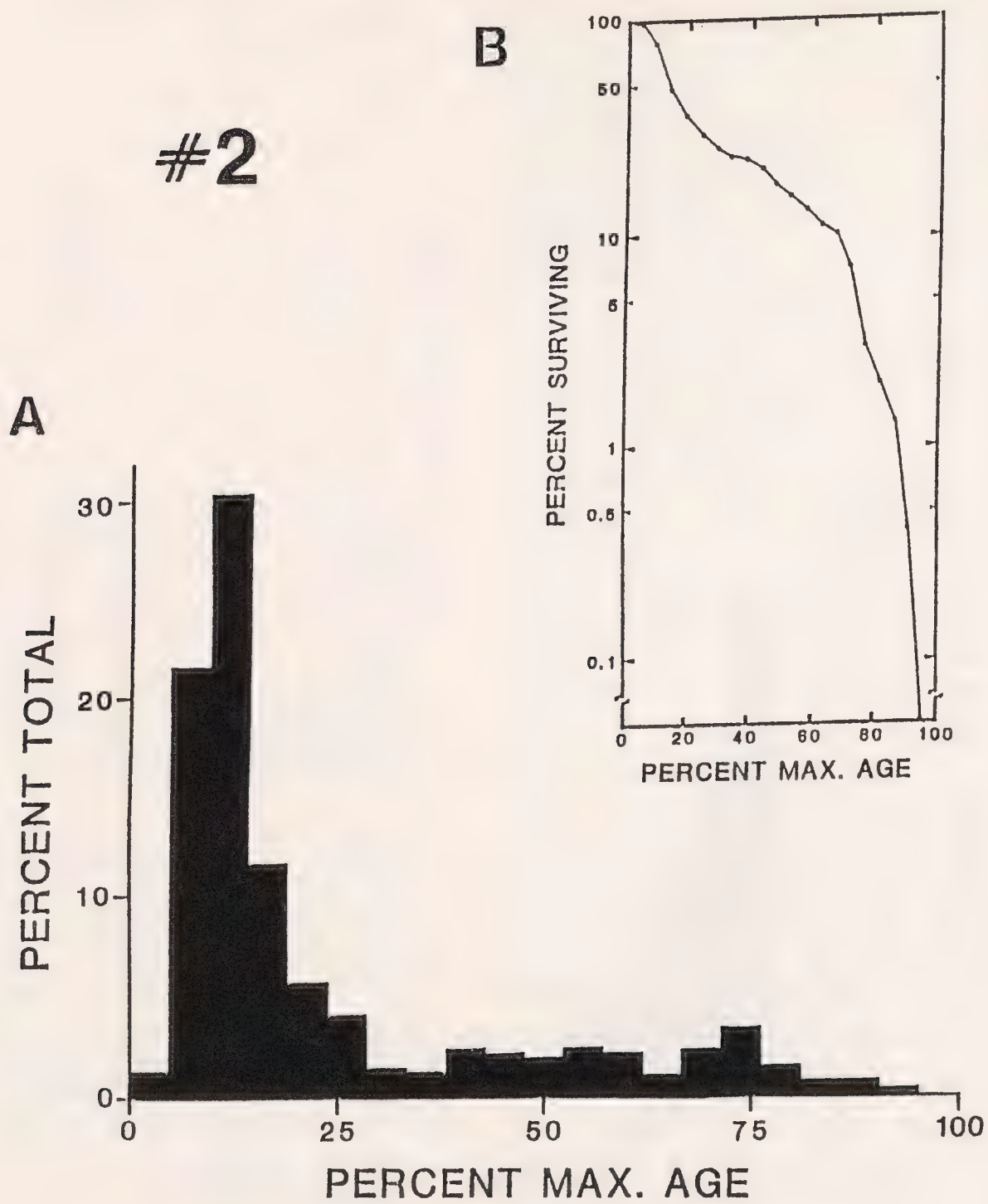

Figure 11. Age-frequency histogram (A), and survivorship curve (B) for *C. fornicata* in *Crepidula* bed sample 2.

pling for this study is consistent with this interpretation. A few species *(C. fornicata, Anadara aequicostata,* and *Nuculana acuta)* comprised upwards of 75% of the preserved faunas of the non-biostromal deposits and *C. fornicata* comprised up to 87% of the *Crepidula* bed fossils. This characteristic is indicative of a somewhat restricted depositional setting. Because the faunas are so similar between the non-biostromal and *Crepidula* biostromal deposits at Johnson Point (including the abundance of *C. fornicata),* the question that begs to be answered is: what were the unique physical or biological factors that supported development of the biostrome? Unfortunately, studies relating the occurrence of living *Crepidula* beds with densities of *C. fornicata* approaching those of the James City strata to physical factors in the environment are scarce. Parker's (1959) classic study of coastal bays in central Texas investigated the distribution of molluscs in ecologic environments for the explicit purpose of providing criteria by which ancient settings could be interpreted. The taxa and sediments of the James City Formation are characteristic of Parker's high salinity bay environments. The faunas of those environments can be grouped into two assemblages: the bay margin assemblage and the bay center assemblage (Parker, 1959). Substrate and circulation are the most important factors separating the two environments. Parker has described "solid *Crepidula* deposits" along the margin of a shallow bay near Rockport, Texas, that receives a steady influx of water from the Gulf of Mexico (1960, written comm. to J. DuBar). Later studies on assemblages faunistically similar to the James City strata have also linked development of high density shell beds dominated by epifaunal suspension feeders to environments having relatively high current velocities.

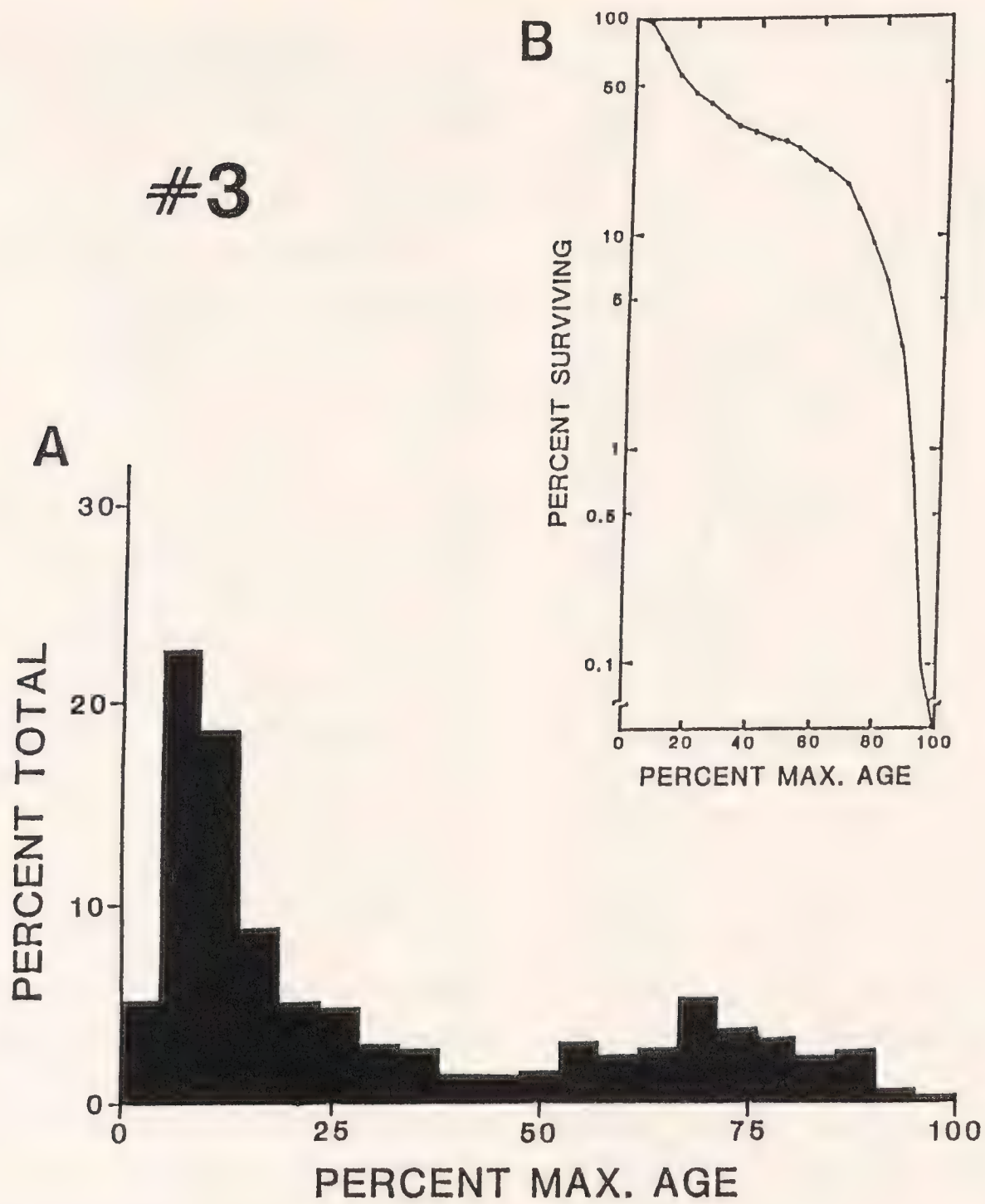

Figure 12. Age-frequency histogram (A), and survivorship curve (B) for *C. fornicata* in *Crepidula* bed sample 3.

Driscoll (1967) found that the hydrography of a shallow protected cove within Buzzards Bay, (Massachussetts), which yielded the greatest densities of *C. fornicata,* was suggestive of the presence of tidal currents strong enough to provide an abundant food supply. The fine sediments in the cove were somewhat more consolidated than those elsewhere in the bay.

Preliminary investigation of a fossil *Vermicularia* biostrome within the Pinecrest beds at Sarasota, Florida (Stanley; in progress) also points to inlet influence within a lagoonal setting.

Contrary to the evidence for inlet influence, Hoagland (1989, written comm.) states that she has observed the densest *Crepidula* beds in Long Island Sound and Vineyard Haven in bays where current velocities were low. So far, no studies have supported a relationship of increased density of *C. fornicata* populations with decreased current velocity, but there is clearly a need for further work in this area.

Origin of Crepidula *Beds*

Although the case for inlet circulation playing the crucial role in determining the presence or absence of *Crepidula* beds in the James City Formation is not conclusive, it is certainly feasible based on the existing evidence from living *Crepidula* beds and the nature of shallow coastal environments. Also, the recurrent nature of *Crepidula* beds at Johnson Point and their alternating occurrence with the barren clay layers tends to suggest a periodic natural distrubance event, such as tidal channel activation, in the ancient environment.

Tidal channels form through bars and barriers as a result of episodic events such as the deep scouring action of storm generated waves. While the channels are active, sedimentation to areas of the bay floor proximal to the inlets tends to be extremely slow, or pre-existing sediments may be eroded (Shepard 1953; Davis, 1983). Inlets are short-lived geologically and inevitably fill up with sediments. When this occurs,

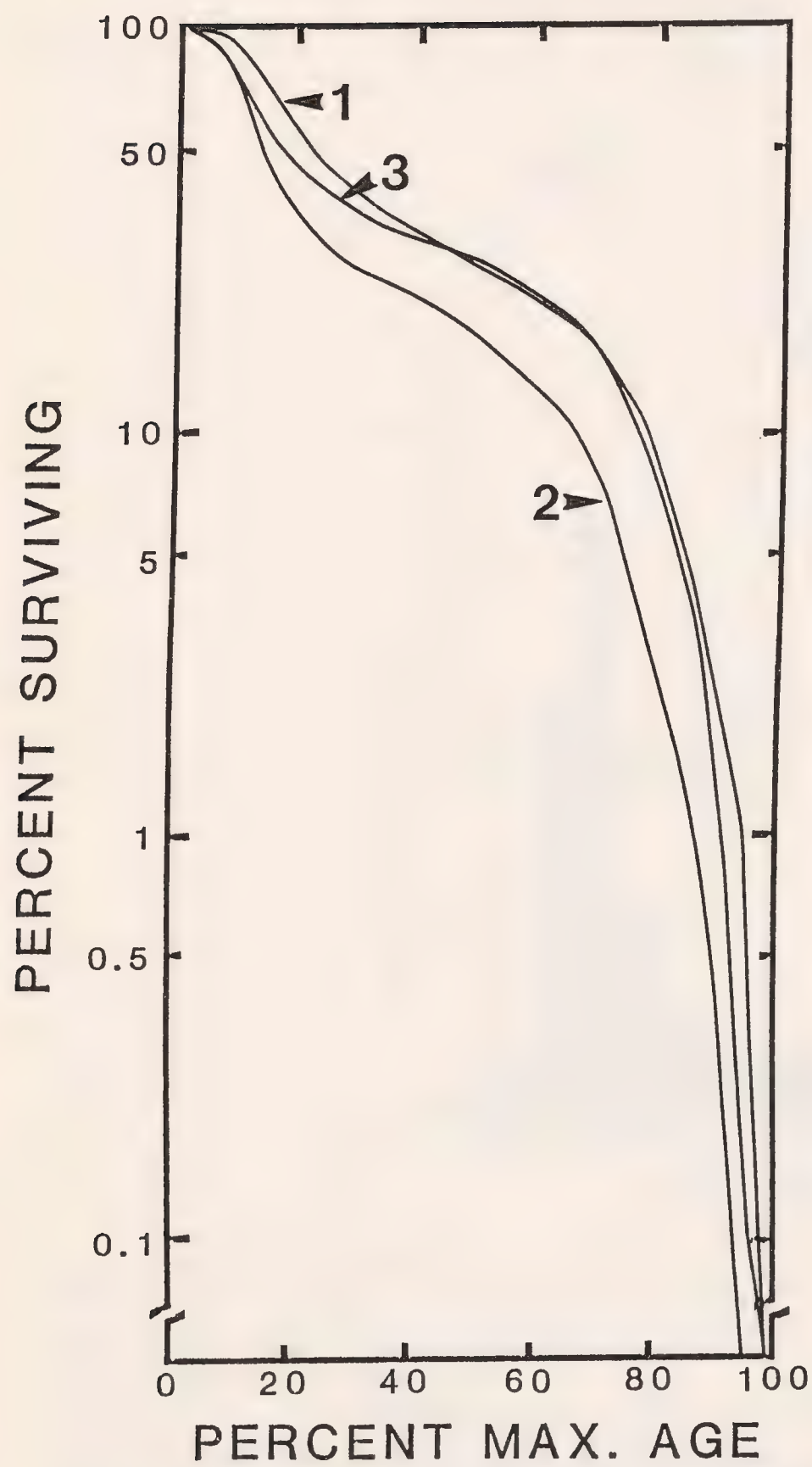

Figure 13. Survivorship curves for the three *Crepidula* populations, which are similar in shape, but differ with respect to apparent ages (sizes) at which changes in mortality occur.

circulation within the basin may revert to a pattern similar to that occurring before the channel opened. Physical consequences of altered current regime, which may bring about the collapse of a biocoenosis, would include a sudden or gradual change in salinity, grain size and/or composition of the sediments caused by a change in the direction of currents, and the onset of sedimentation in areas that previously received no sediment, due to a change in current direction (Schafer, 1972). Biological consequences of a shift in circulation pattern might be: fouling by increased levels of excretory substances (*i.e.*, feces) among the dense populations due to a decrease in the velocity of bottom currents, and rapid or gradual starvation due to a decrease in the velocity of feeding currents.

Termination of *Crepidula* biostromal production in the James City Formation was probably related to changes in hydrography (*e.g.*, migration of the inlet) of the basin.

Two possible consequences of tidal channel activation proposed herein as mechanisms in the formation of the James City *Crepidula* beds are population resurgence, and reduction in sedimentation. R. G. Johnson's study (1960) was one of the first promoting the concept of fossil density as a function of relative rates of hardpart input and sedimentation. He described three basic ways by which richly fossiliferous deposits might be produced. They are: (1) if hardpart input were to increase against a background of constant sediment supply; (2) if sedimentation decreased while the rate of hardpart input remained constant; or (3) if both rates varied in such a way as to result in net increase in hardpart input relative to sediment supply.

The James City *Crepidula* layers possess a strongly biogenic signature, due to the spatial distribution of skeletal elements within them. Accumulations of this type are produced by the intrinsic gregarious behavior of the organisms whose skeletons make up the units (Kidwell, Fursich and Aigner, 1986). As previously stated, stacking and the preferential colonization of substrates already occupied by adults of their species by *C. fornicata* larvae are the primary factors responsible for the distribution pattern in the *Crepidula* beds.

In modern settings, drastic increases in numbers of certain species of invertebrates have been observed over relatively short periods of time (*e.g.*, a few years). Groups that exhibit this type of behavior have been termed "resurgent populations" by Coe (1957).

The following depicts a sequence of events, following the enhancement of feeding currents through tidal channel activation, that may describe the mode of occurrence (and decline) of the James City *Crepidula* beds (see Fig. 14).

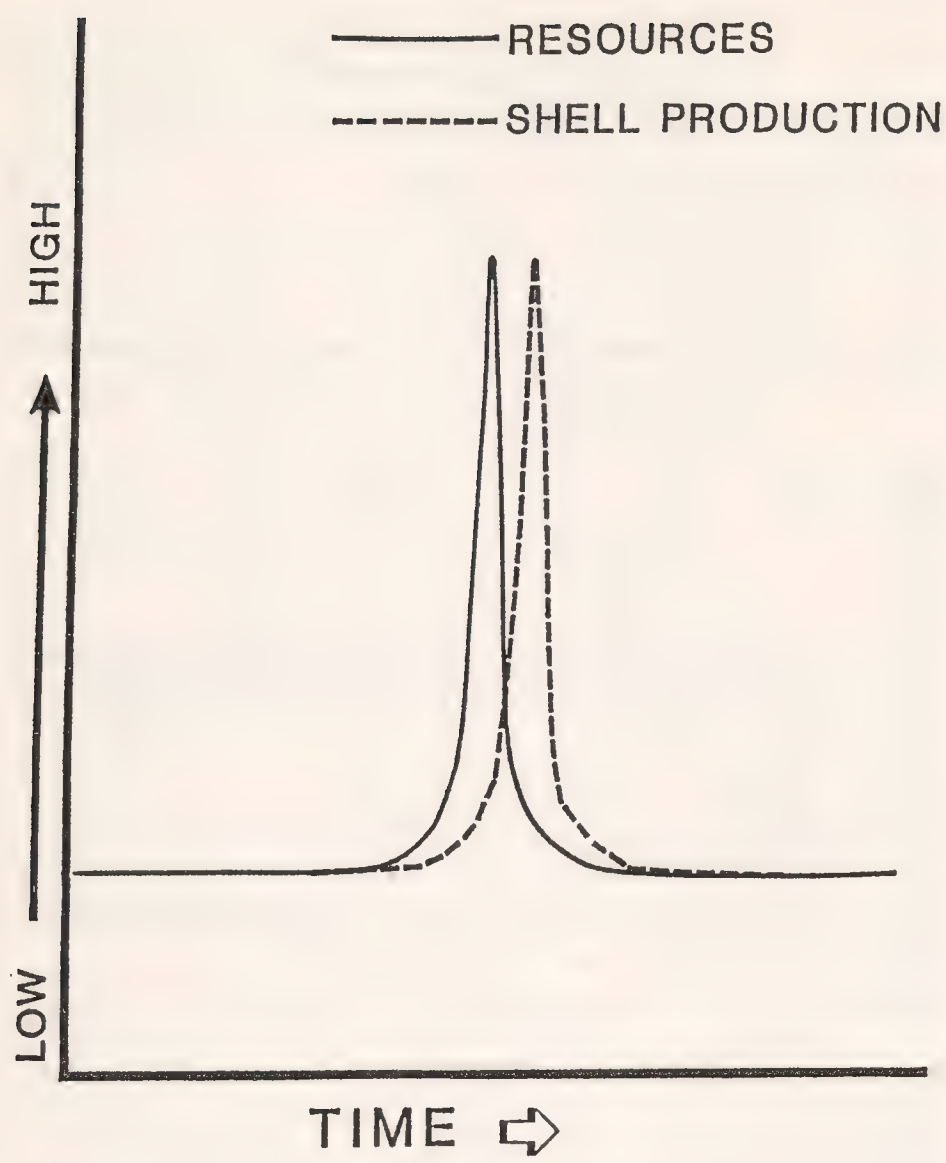

Figure 14. The Resurgent Population Mechanism.

1. The sudden availability of a previously limited resource significantly raises the carrying capacity for the environment, and induces the rapid population growth of an innately fecund species.
2. In a relatively short period of time, the resurgent species attains a population density that is commensurable with the environment's new carrying capacity.
3. A sudden or gradual reduction in the critical resource leads to either a catastrophic or stepwise decline in the resurgent population. The temporal scope of population resurgence and decline is on the order of years to tens of years, or within *ecologic* time.

The Resurgent Population Mechanism proposes that the enhancement of a critical resource in the environment, coupled with the fecundity and resource utilization abilities of a particular species were the crucial ingredients in the production of the *Crepidula* beds. The main selling points in this explanation are simplicity and feasibility. Enhanced nutrients would be a direct result of strong current activity in the ancient environment. In addition, the likelihood of resurgence in *C. fornicata* populations seems feasible, given the ecologic and biologic background of the species, and the fact that fluctuations of this sort are known to be widespread in benthic communities. There is, however, a considerable degree of variability in capacity of groups to fluctuate, which complicates the simple idea of formation through relatively rapid hardpart input. In other words, could the increase in shell-production rate alone have been sufficient to produce the dense beds? Invoking another influence in the origin of the beds (*i.e.*, sedimentation) necessarily comes to bear on the question of temporal scope.

The *Crepidula* beds are ecological oddities in that they are composed predominantly of epifaunal suspension feeders, but occur in fine-grained sediment. The co-occurrence of these two features contradicts a well recognized concept regarding the influence of sediment on benthos, *viz.*, deposit feeders tend to be more abundant in muddy sand, and suspension feeders are more likely to predominate in shell/gravel grounds (Craig and Jones, 1966). However, Hoagland states (1989, written comm.) that in muddy sediments, the large *Crepidula* stacks are not attached to the substrate, are often in direct contact with the mud, and can roll around on the bottom in strong currents.

Reduced sedimentation rate provides an explanation for the development of dense shell beds dominated by epifaunal organisms in a mud bottom setting. The sequence of events might be as follows (see Fig. 15).

1. Initial colonization of the muddy substrate is by opportunistic species, which are most likely deposit feeders, but could also be specially adapted suspension feeders or sediment floaters.
2. Shell production exceeds the rate of sedimentation locally transforming the soft ground into firm ground, and colonization by epifaunal suspension feeders is permitted.
3. As more and more carbonate material is introduced to the substrate through death and fragmentation of the shelled community members, epifaunal

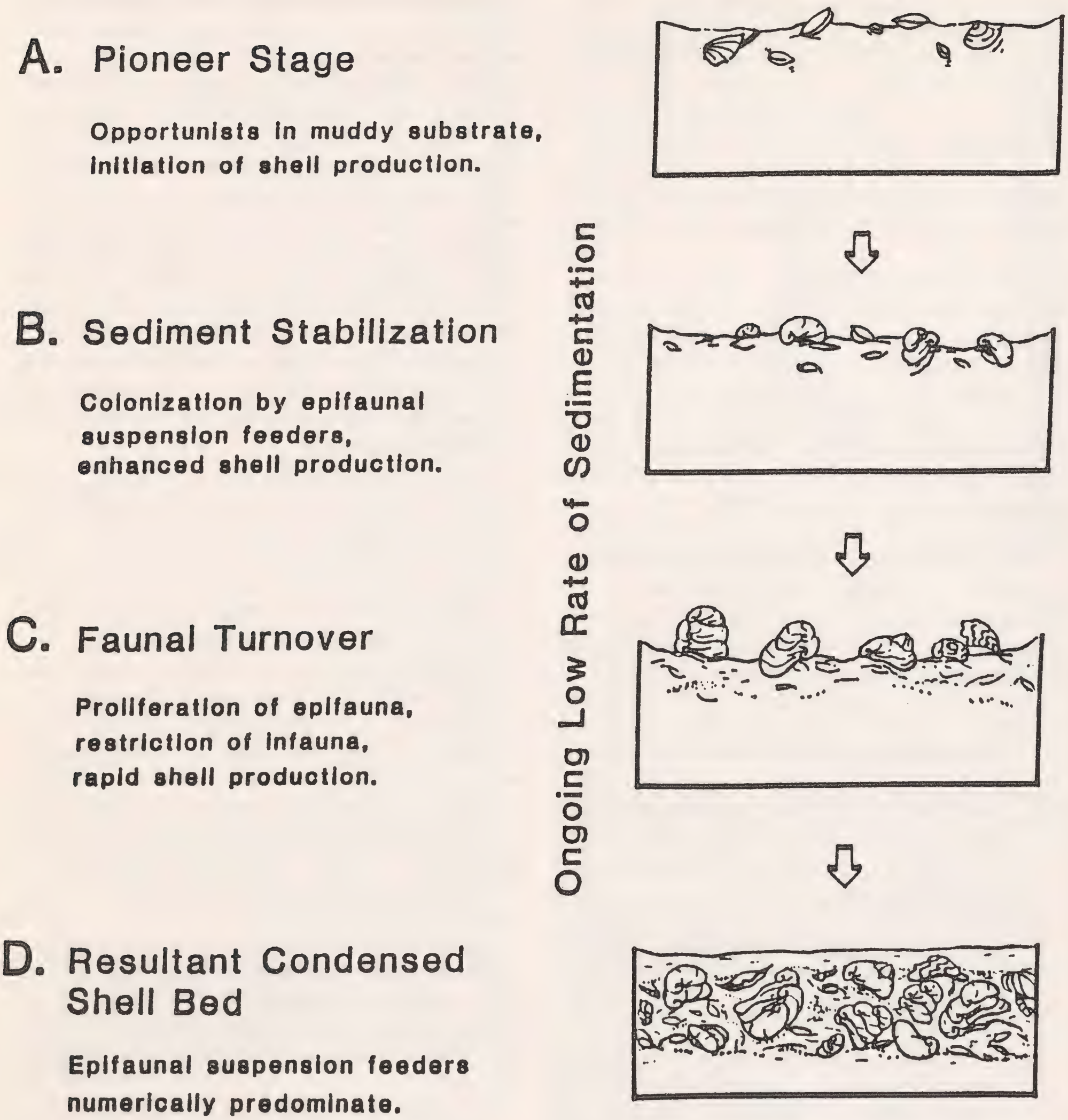

Figure 15. The Reduced Sedimentation Mechanism.

organisms become more prolific, while deposit feeders undergo spatial restriction.

4. Faunal transformation, which is already in progress, is facilitated by the fecundity of epifaunal species involved, and the situation eventually gives way to complete faunal turnover and the establishment of a complex, structured community dominated by suspension feeders.

Reduced sedimentation provides a sensible explanation for several important characteristics of the James City *Crepidula* beds, particularly the predominance of epifaunal suspension feeders in a mud bottom setting. Unfortunately, this can not be entirely proven on the basis of observed features of the shell beds. The salient features of the Reduced Sedimentation Mechanism are: reduction in sedimentation relative to shell production; local firm

ground development; and faunal turnover. Evidence of these three processes might be: high shell/matrix ratios; inhomogeneity of sediments between the dense shell beds and intervening layers, with the possible occurrence of omission surfaces; and mixed faunal assemblages, including opportunistic and soft-bottom infaunal, and firm ground (epifaunal) inhabitants.

High shell/matrix ratios in the beds only indicate that sedimentation was slow relative to shell input. If a high rate of shell production due strictly to biologic processes had occurred in conjunction with a constant rate of sedimentation, the net effect would be the same (Johnson, 1960). As in the case of population resurgence, there is a question of relative influence that comes to bear on the problem of temporal scope. Still, reduced sedimentation is consistent with the environmental interpretation. If the beds were deposited in an area of the basin that was receiving inlet circulation, then they had the lowest rate of sedimentation of any of the bay environments. The necessary sedimentologic clues of reduced sedimentation (*e.g.*, inhomogeneity and omission surfaces) are not available. All traces of bedding have been obliterated in the units through intense bioturbation, as have such features as the nature of the original stratigraphic contacts. The overprinting of time and sedimentologic processes on biologic events, (and vice versa), makes it extremely difficult to interpret original community dynamics. Faunal analysis of the *Crepidula* beds shows them to contain a mixture of epifaunal and infaunal species. This may suggest a change in substrate characteristics and faunal turnover, but could also be the result of other factors, including mixing of taxa from adjacent environments.

VII. CONCLUSIONS

The James City *Crepidula* beds are biogenic accumulations, produced primarily through episodes of resurgence by *Crepidula fornicata* populations. These events occurred in response to periodic increases in current velocity (and nutrients) in a shallow, semi-restricted basin. Tidal channel activation through natural disturbances was the likely catalyst for the production of these units. A reduced rate of sedimentation during periods of enhanced currents probably contributed significantly to the suitability of that environment for habitation by epifaunal suspension feeders in general, and *C. fornicata* in particular.

The *Crepidula* bed communities were physically controlled communities whose compositions varied under the direct influence of the physical environment. An environmental gradient along which substrate, as well as other parameters, changed in a continuous fashion is reflected in the faunal compositions of the *Crepidula* beds. Aspects of the *C. fornicata* populations (mortality, growth, recruitment, and morphologic variablity) were likewise largely controlled (directly and indirectly) by environmental factors.

VIII. ACKNOWLEDGMENTS

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IX. REFERENCES

BLACKWELDER, B. W., 1981, Stratigraphy of Upper Pliocene and Lower Pleistocene marine and estuarine deposits of northeastern North Carolina and southeastern Virginia: U. S. Geol. Surv., Bull. 1502-B, 16 p.

BLATT, H., 1982, Sedimentary Petrology. San Francisco, W. H. Freeman and Company, 563 p.

COE, W. R., 1936, Sexual phases in *Crepidula:* Jour. Exp. Zool., v. 72, p. 455-477.

COE, W. R., 1938a, Conditions influencing change of sex in mollusks of the genus *Crepidula:* Jour. Exp. Zool., v. 77, p. 401-424.

COE. W. R., 1938b, Influence of association on the sexual phases of gastropods having protandric consecutive sexuality: Biol. Bull., v. 75, p. 274-285.

COE, W. R., 1942, Influence of natural and experimental conditions in determining shape of shell and rate of growth in gastropods of the genus *Crepidula:* Jour. Morphology, v. 71, p. 35-51.

COE, W. R., 1957, Fluctuations in littoral populations, *in* J. W. HEDGPETH, ed., Treatise on Marine Ecology and Paleoecology: Geol. Soc. Amer., Memoir 67, v. 1, p. 935-940.

CRAIG, G. Y., and A. HALLAM, 1963, Size-frequency and growth-ring analysis of *Mytilus edulis* and *Cardium edule,* and their paleontological significance: Palaeontology, v. 6, no. 4, p. 731-750.

CRAIG, G. Y., and N. S. JONES, 1966, Marine benthos, substrate and paleoecology: Palaeontology, v. 9, no. 1, p. 30-38.

CRONIN, T. M., L. M. BYBELL, R. Z. POORE, B. W. BLACKWELDER, J. C. LIDDICOAT, and J. E. HAZEL, 1984, Age and correlation of emerged Pliocene and Pleistocene deposits, U. S. Atlantic Coastal Plain: Paleogeography, Paleoclimatology, Paleoecology, v. 47, p. 21-51.

DAVIS, R. A., 1983, Depositional Systems - A Genetic Approach to Sedimentary Geology. New Jersey, Prentice-Hall, Inc., 669 p.

DODD, J. R., and R. J. STANTON, JR., 1981, Paleoecology, Concepts and Applications. New York, John Wiley and Sons, 559 p.

DRISCOLL, E. G., 1967, Attached epifauna-substrate relations: Limnology and Oceanography, v. 12, p. 633-641.

DRISCOLL, E. G., and D. E. BRANDON, 1973, Mollusc-sediment relations in Northwestern Buzzards Bay, Massachusetts, U. S. A.: Malacologia, v. 12, no. 1, p. 13-16.

DUBAR, J. R., and J. R. SOLLIDAY, 1963, Stratigraphy of the Neuse deposits, Lower Neuse estuary, North Carolina: Southeastern Geology, v. 4, p. 213-233.

DUBAR, J. R., J. R. SOLLIDAY, and J. H. HOWARD, 1974, Stratigraphy and morphology of Neogene deposits, Neuse River estuary, North Carolina, *in* R. Q. OAKS, JR. and J. R. DUBAR, eds., Post-Miocene Stratigraphy, Central and Southern Atlantic Plain. Logan, Utah State University Press, p. 102-122.

FOLK, R. L., 1965, Petrology of Sedimentary Rocks. Austin, Texas, Hemphill's, 159 p.

HALLAM, A., 1972, Models involving population dynamics, *in* T. J. M. SCHOPF, ed., Models in Paleobiology. San Francisco, Freeman, Cooper, and Co., p. 62-80.

HOAGLAND, K. E., 1977, Systematic review of fossil and Recent *Crepidula* and discussion of evolution of the Calyptraeidae: Malacologia, v. 16, no. 2, p. 353-420.

HOAGLAND, K. E., 1978, Protandry and the evolution of environmentally-mediated sex change: a study of the Mollusca: Malacologia, v. 17, no. 2, p. 365-391.

HOAGLAND, K. E., 1979, The behavior of three sympatric species of *Crepidula* (Gastropoda:Prosobranchia) from the Atlantic, with implications for evolutionary ecology: Nautilus, v. 94, no. 4, p. 143-149.

JOHNSON, J. K., 1971, Effect of turbidity on the rate of filtration and growth of the slipper limpet, *C. fornicata:* Veliger, v. 14, no. 3, p. 315-320.

JOHNSON, R. G., 1960, Models and methods for analysis of the mode of formation of fossil assemblages: Geol. Soc. Amer., Bull., v. 71, p. 1075-1086.

JOHNSON, R. G., 1972, Conceptual models of benthic marine communities, *in* T. J. M. SCHOPF, ed., Models in Paleobiology. San Francisco, Freeman, Cooper and Co., p. 148-159.

KIDWELL, S. M., 1982, Time scales of fossil accumulation: patterns from Miocene benthic assemblages: Third North American Paleontological Convention Proceedings, v. 1, p. 295-300.

KIDWELL, S. M., F. T. FURSICH, and T. AIGNER, 1986, Conceptual framework for the analysis and classification of fossil concentrations: Palaios, v. 1, p. 228-238.

LOOMIS, S. H., and W. VAN NIEUWENHUYZE, 1985, Sediment correlates to density of *Crepidula fornicata* Linneaus in the Pantanguanset River, Connecticut: Veliger, v. 27, no. 3, p. 266-272.

MACARTHUR, R. H., and J. H. CONNELL, 1966, The Biology of Populations. New York, Wiley, 200 p.

MARGALEF, R., 1968, Perspectives in Ecological Theory. Chicago, University of Chicago Press, 111 p.

MILLER, W., III, 1989, Checklist of megafossils from the James City Formation (Lower Pleistocene) at Johnson Point, Craven County, North Carolina: Tulane Stud. Geol. Paleont., v. 22, no. 3, p. 93-100.

MILLER, W., III, and J. R. DUBAR, 1988, Community replacement of a Pleistocene *Crepidula* biostrome: Lethaia, v. 21, p. 67-78.

PARKER, R. H., 1959, Macro-invertebrate assemblages of Central Texas coastal bays and Laguna Madre: Amer. Assoc. Petrol. Geol., Bull., v. 43, p. 2100-2166.

PURCHON, R. D., 1977, The Biology of the Mollusca, 2nd Edition. Oxford, Pergamon Press, 560 p. RICHARDS, R. P., and R. K. BAMBACH, 1975, Population dynamics of some Paleozoic brachiopods and their paleoecologic significance: Jour. Paleontology, v. 49, p. 775-798.

SCHAFER, W., 1972, Ecology and Paleoecology of Marine Environments. Chicago, The University of Chicago Press, 568 p.

SHEPARD, F. P., 1953, Sedimentation rates in Texas bays: Amer. Assoc. Petrol. Geol., Bull., v. 37, no. 8, p. 1919-1934.

STANLEY, S. M., 1968, Post-Paleozoic adaptive radiation of infaunal bivalve mollusks - a consequence of mantle fusion and siphon formation: Jour. Paleontology, v. 42, p. 214-229.

STANLEY, S. M., 1970, Relation of shell form to life habits of the Bivalvia (Mollusca): Geol. Soc. Amer., Memoir 125, 296 p.

VIGNETTES OF COASTAL PLAIN GEOLOGY

TRUMAN HEMINWAY ALDRICH
1848-1932

T. H. Aldrich may be considered the last of the great pioneers of American Tertiary paleontology. Born in Palmyra, New York, in 1869 he graduated from Rensselaer Polytechnic Institute as a mining engineer. After school he went to work in Alabama and it was his discovery of the large coking coal deposits of northern Alabama that were largely responsible for the development of the steel industry of Birmingham. Not only was he active in the coal fields of Alabama, but an ardent amateur paleontologist. In 1886 he published his first major work, Alabama Geological Survey Bulletin 1, in which he described over 50 new species of Eocene Mollusca. For the next forty years he contributed numerous short works on the fossil species that he had collected. On the occasion of his 80th birthday the University of Alabama gave him an honorary Doctor of Science degree, in recognition of his great service to the industrial and intellectual development of the state. (*From* Julia Gardner, 1933, Geological Society of America, Bulletin, v. 44)

CHECKLIST OF MEGAFOSSILS FROM THE JAMES CITY FORMATION (LOWER PLEISTOCENE) AT JOHNSON POINT, CRAVEN COUNTY, NORTH CAROLINA

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INTRODUCTION

Richly fossiliferous beds exposed along the northern edge of Johnson Point, south shore of the Neuse River (Figure 1), have been the focus of several recent studies (Miller, 1986a, 1986b; Zullo and Miller, 1986; Woods, 1987; Miller and DuBar, 1988). The locality was first described by DuBar *et al.* (1974, p. 111) as the site of an extensive *Crepidula fornicata* biostrome within the James City Formation. Because of the interest being lavished on the locality it is important to have a catalogue available of all the megafossil remains that have been collected to date. Moreover, in a geographic area where fossil localities in river banks are notoriously evanescent, full documentaion of species occurrences at significant sites like Johnson Point is clearly desirable. The purpose of my note is to provide this documentation in the form of a stratigraphic checklist (Table 1) together with illustrations of the more common species (Plate 1). The list includes rare faunal elements not reported in paleoecologic studies (Zullo and Miller, 1986; Miller and DuBar, 1988). Illustrations should be useful in the recognition of James City beds in isolated outcrops in the Neuse River valley. All fossils in this list came from a series of one-litre bulk sediment samples taken from one part of the outcrop in 1982 after undercutting of the river bank had exposed unweathered beds. The aim at that time was to sample each bedding unit present in the fresh exposure. Figure 1 shows the sampled section and Table 1 contains fossil inventories for each of the samples. Additional collecting in this way no doubt would lengthen the roster, but the present compilation at least provides a preliminary checklist.

STRATIGRAPHIC CONTEXT

Regional. – The James City Formation was named by DuBar and Solliday (1963), who designated the river bank exposures near Grantham as the type section (Figure 1). They regarded the unit as possibly Pliocene in age, being situated unconformably below the Pleistocene Flanner Beach Formation. Later work on foraminiferids and mollusks showed the type James City to be early Pleistocene (DuBar *et al.*, 1974). This age revision has been confirmed subsequently by multiple lines of evidence (Blackwelder, 1981a; McCartan *et al.*, 1982). The James City is usually considered time-equivalent with the Waccamaw Formation in southeastern North Carolina and northeastern South Carolina, and with the Caloosahatchee Formation in Florida. However, Cronin *et al.* (1984, p. 45-46) proposed recently that the James City may be slightly younger (1.3-0.7 Ma) than the main part of the Waccamaw. The outdated term "Croatan Formation" has been applied to James City equivalents exposed in the Lee Creek phosphate mine 40 km to the north in Beaufort County (see Ray, 1983).

General depositional environment of the James City in its type area was a shallow, subtropical marine bay having fairly open communication with the ocean (DuBar and Howard, 1969; DuBar *et al.*, 1974; Blackwelder, 1981b). More restricted estuarine facies appear to be preserved at the Fountain quarry locality, Pitt County, described by Snyder and Katrosh (1979); a deeper water, bay-center facies crops out at an isolated downstream locality on the Neuse River near Dam Creek, Craven County (Fallaw and Wheeler, 1969, p. 52 and Plate 4, Fig. 1; Miller, 1985, Zullo and Miller, 1986). These deposits accumulated during an early Pleistocene high stand of sea level to approximately +25 m MSL, which Blackwelder (1981b, Fig. 2) attributed to a warm period occurring between two glacial pulses recognized in South America. The onset of cooler marine climates in the Western Atlantic Ocean and regression of the shelf sea terminating the James City depositional cycle appear to have resulted in extinction of roughly 17% of the mollusks listed here (see Blackwelder, 1981b; Stanley, 1986). Extinct species are designated with an asterisk in Table 1 and discussed below.

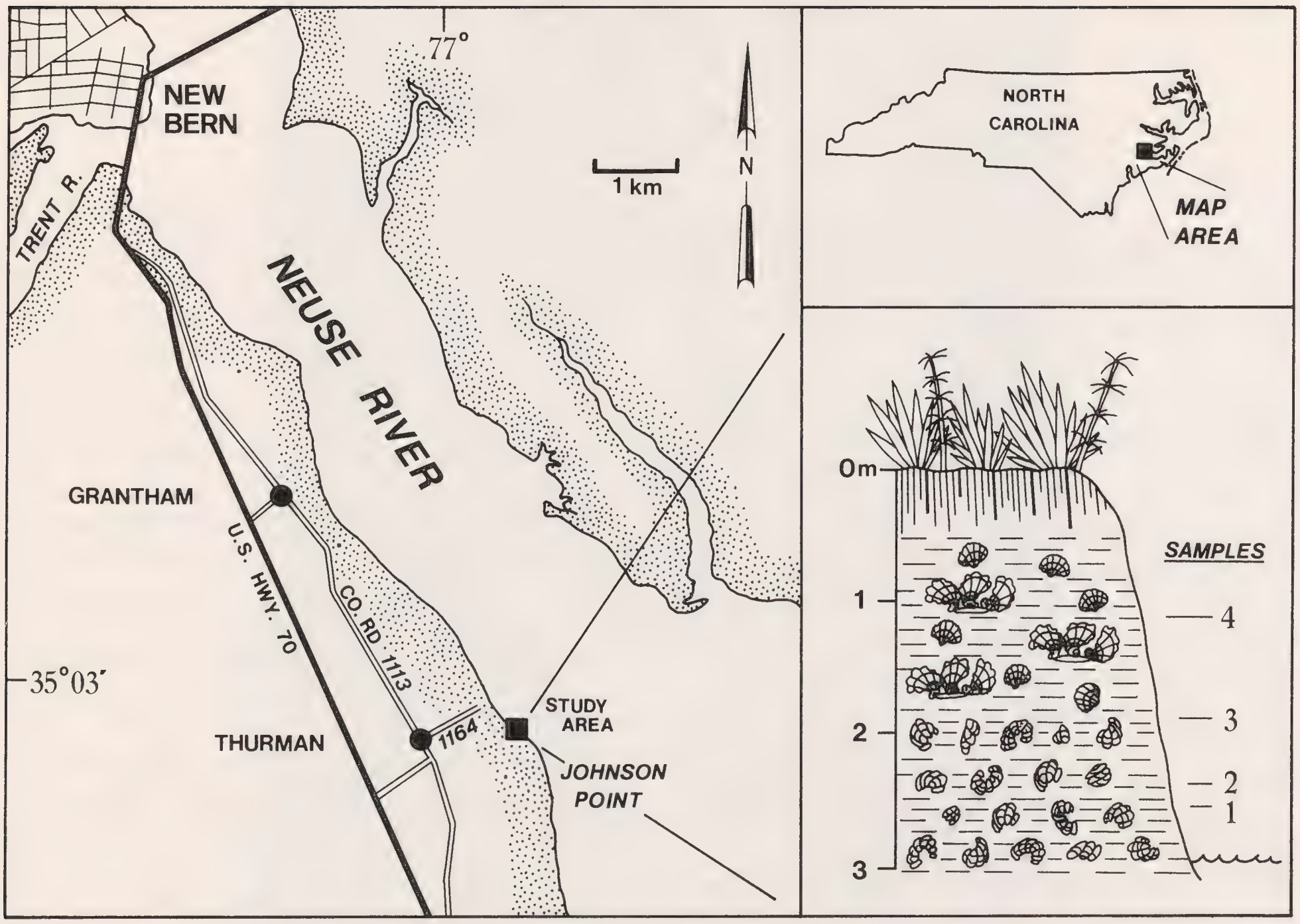

Figure 1. Location of Johnson Point in North Carolina Coastal Plain, showing stratigraphic section sampled in 1982. (Sample numbers same as those used in Table 1. River level is approximately mean sea level.)

Johnson Point Section. – The locality extends from the end of County Road 1164 (from which it can be easily reached) to the tip of Johnson Point, in a low vertical mudstone bank. Sediments are mostly medium bluish gray (5 B 5/1) to olive gray (5 Y 3/2), slighty indurated, shelly sandy mudstone to siltstone containing up to six shelly interbeds each about 10 cm thick. The only visible stratification is in the form of these laterally discontinuous shelly accumulations. Many epibenthic-attached and endobenthic bivalves are in living positions or only slightly disturbed indicating that the fossil deposits are largely autochthonous (Figure 2).

Johnson Point is notable for the occurrence of a well perserved biostrome in the lower 1.0 to 1.5 m of the exposure consisting of stacks of the slipper snail, *Crepidula fornicata* (Figure 2a). DuBar *et al.* (1974, p. 111) were the first to describe this fossil shell bank, which extends for 150 m along the outcrop face. The *Crepidula* biostrome (Table 1, samples 1 and 2) is succeeded by a slighty coarser mudstone bed rich in endobenthic bivalves and varied carnivorous/scavenging gastropods (samples 3 and 4). This bed contains many *Anadara aequicostata* with valves still conjoined (Figure 2b), as well as occasional clumps of *Ostrea sculpturata*. Population-level patterns within the *Crepidula* buildup have been described in detail by Woods (1987). The demise of the biostrome and replacement by a more diverse assembly of benthic organisms resulted from gradual habitat alteration and increase in environmental heterogeneity, possibly owing to local shoaling of the seafloor (Miller and DuBar, 1988).

This is the type locality for the newly described balanid barnacle, *Balanus neusensis* Zullo and Miller, 1986 (Plate 1, fig. 20), which appears to have biostratigraphic potential in correlating early Pleistocene

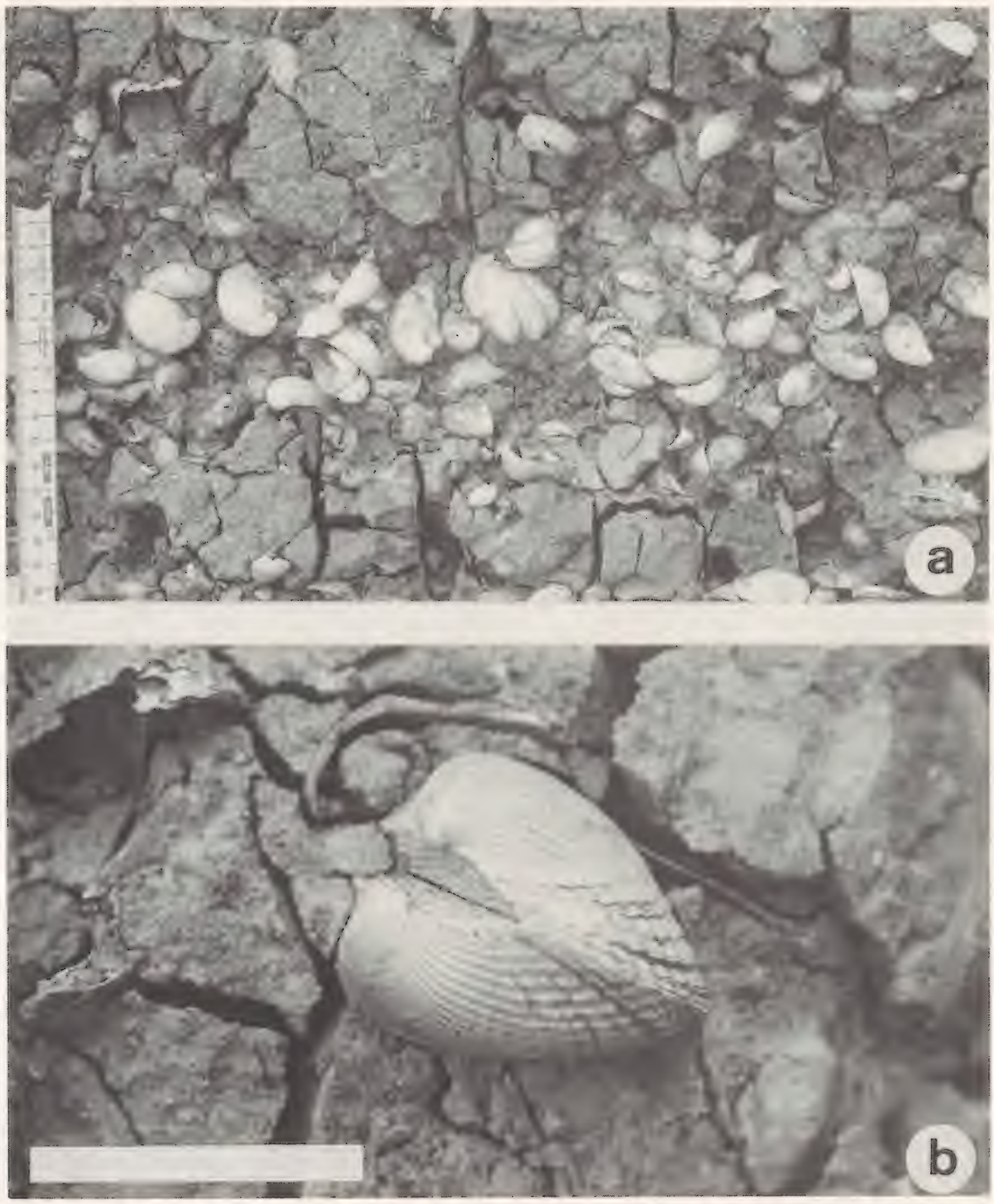

Figure 2. *a*, Shell layer with abundant *Crepidula fornicata* in lower part of exposure (ruler graduated in cm's); *b*, *Anadara aequicostata* in upper part of exposure (bar scale represents 3 cm).

marine deposits in the Carolinas.

NOTES ON MOLLUSKS

Of the more than 70 species identified in samples, 59 are mollusks. Nearly half of these are small and rare. Eighteen of the 37 gastropods (48.6%) and 9 of the 21 bivalve species (42.9%) are represented by 10 or fewer individuals. Only 9 of the 59 mollusk species (15.3%) are numerically abundant in all samples. These include *Crepidula fornicata*, a high-spired variety of *Anachis lafresnayi*, *Anachis obesa*, *Nassarius albus*, *Boonea seminuda*, *Nuculana acuta*, *Anadara aequicostata*, *Ostrea sculpturata*, and *Abra aequalis*, all of which are represented by complete growth series with many juvenile specimens. Uncommon but conspicuous specimens of *Busycon* sp., *Noetia limula*, *Ar-*

Table 1. List of fossils from the James City Formation at Johnson Point. Sample numbers refer to Figure 1. Counts are specimen tallies corrected to estimate numbers of individual organisms (e. g., for bivalves 1 beak fragment = 1/2 individual). Because of mode of preservation (e.g., dismembered zoaria of fragile bryozoans), abundance of certain organisms given as: A, abundant; C, common; R, rare. Extinct taxa indicated with *.

TAXA	SAMPLES			
	1	2	3	4
GASTROPODA				
Cyclostremiscus obliquistriatus (H. C. Lea, 1843)*	–	–	–	1
Vermicularia cf. *knorrii* (Deshayes, 1843)	–	–	–	12
Cerithiopsis emersoni (C. B. Adams, 1838)	–	–	2	–
C. vinca Olsson & Harbison, 1953*	–	1	3	3
Seila adamsi (H. C. Lea, 1845)	4	1	7	6
Triphora dupliniana (Olsson, 1916)*	–	–	1	1
Triphora sp.	–	–	1	–
Epitonium apiculatum (Dall, 1889)	1	2	2	10
Melanella conoidea Kurtz and Stimpson, 1851	2	–	3	18
M. intermedia (Cantraine, 1835)	–	–	7	1
?*Melanella* sp.	–	1	–	–
Crepidula fornicata (Linné, 1758)	1292	545	586	447
C. convexa Say, 1822	1	2	2	2
C. plana Say, 1822	12	6	7	5
Crepidula sp.	–	–	–	1
Polinices sp.	–	3	2	14
Urosalpinx cinerea (Say, 1822)	5	2	13	17
Anachis lafresnayi (Fischer and Bernardi, 1856) var.	48	18	18	37
A. obesa (C. B. Adams, 1845)	30	25	19	21
Anachis sp.	6	–	–	–
Mitrella lunata (Say, 1826)	4	2	2	8
Busycon sp.	8	1	12	1
Nassarius albus (Say, 1826)	27	8	11	15
Olivella sp.	–	–	–	1
Prunum sp.	3	3	1	13
Hyalina sp.	–	–	1	3
? Turridae indet.	–	1	–	–
Booonea seminuda (C. B. Adams, 1837)	758	434	543	434
B. impressa (Say, 1821)	2	2	21	36
Odostomia conoidea (Brocchi, 1814)	–	–	1	–
Odostomia sp.	2	–	1	–
?*Odostomia* sp.	–	–	–	1
Turbonilla (Chemnitzia) sp.	–	3	22	19
T. (Pyrgiscus) sp. A	6	4	8	23
T. (Pyrgiscus) sp. B	2	1	7	8
Ringicula sp.	–	–	2	–
Acteocina candei (Orbigny, 1842)	1	–	–	–
BIVALVIA				
Nucula proxima Say, 1822	6	7	8	16
Nuculana acuta (Conrad, 1832)	138	62	144	287
Yoldia limatula (Say, 1831)	4	1	4	10
Anadara aequiscostata (Conrad, 1845)*	70	28	52	201
Noetia limula (Conrad, 1832)*	–	1	–	12
Modiolus sp.	–	–	1	5
Argopecten eboreus (Conrad, 1833)*	1	1	1	2
Ostrea sculpturata Conrad, 1840*	122	55	130	300
Parvilucina multilineata (Tuomey and Holmes, 1857)	–	1	–	1
Diplodonta sp.	–	–	–	1
Bornia longipes (Stimpson, 1855) var.	–	–	–	3
Ensitellops protexta (Conrad, 1841)	3	1	3	9

Spisula sp.	–	–	1	–
Mulinia lateralis (Say, 1822)	3	2	24	23
Ensis sp.	–	–	1	–
Tellina aff. *texana* Dall, 1900	–	–	–	1
Cumingia tellinoides (Conrad, 1831)	4	3	8	29
Abra aequalis (Say, 1822)	10	6	13	112
Mercenaria permagna (Conrad, 1838)*	7	4	14	28
Calloardia sayana (Conrad, 1833)	–	–	1	2
Sphenia sp.*	7	6	21	54
Corbula conradi Gardner, 1943*	–	1	2	10
Hiatella arctica (Linné, 1767)	–	1	2	4
POLYPLACOPHORA				
Chaetopleura sp.	1	1	1	2
CRUSTACEA				
Balanus spp.	224	124	210	218
Brachyura indet.	5	6	9	38
BRYOZOA				
Terebripora sp.	–	R	–	–
Spathipora sp.	C	C	A	C
Electra sp.	R	C	C	C
Cyclocolposa perforata Canu and Bassler, 1923	A	A	C	A
Cribrilina punctata (Hassall, 1841)	C	C	C	C
Celleporaria cf. *albirostris* (Smitt, 1873)	R	–	–	C
Hippoporina cf. *pertusa* (Esper, 1796)	C	C	C	C
Hipporprella cf. *gorgonensis* Hastings, 1930	–	–	R	–
DEMOSPONGIAE				
?*Cliona* spp.	C	C	C	C
POLYCHAETA				
Polydora spp.	C	C	C	C
?*Hydroides* sp.	R	–	–	–
SCLERACTINIA				
Septastrea sp.	R	R	–	R
ECHINOIDEA				
Clypeasteroida indet.	–	–	R	R
PISCES				
shark teeth	–	1	–	–
small teleost vertebrae	–	1	2	–

gopecten eboreus, and *Mercenaria permagna* are the mollusks normally recovered when surface-picking is the sole means of collection. Works consulted in the determination of mollusk species included: Tuomey and Holmes, 1857; Gardner, 1943, 1948; Olsson and Harbison, 1953; Waller, 1969; Abbott, 1974; Blackwelder, 1981c.

Beds exposed at Johnson Point are within Blackwelder's (1981c) molluscan zone M3, or *Glycymeris subovata-Anadara ovalis* Interval Zone (defined as the interval between last appearance of *G. subovata* and first appearance of *A. ovalis*). Zone M3 delineates the Windyan Substage of the Colerainian Stage, regional chronostratigraphic divisions of the Late Cenozoic in the Atlantic Coastal Plain (Blackwelder, 1981c, Text-fig. 1). Several extinct bivalves restricted to the Colerainian in the Carolinas occur at Johnson Point: *Anadara*

aequicostata, *Noetia limula*, *Ostrea sculpturata*, and *Mercenaria permagna* (see Plate 1). The extinct scallop *Argopecten eboreus*, which is rare in samples, ranges through the Burwellian (includes the upper part of the Yorktown Formation) and Colerainian stages. Other extinct bivalves in the checklist with unknown stratigraphic durations are *Corbula conradi* and a possible new species of *Sphenia* (Plate 1). In addition, three species of small snails apparently are extinct: *Cyclostremiscus obliquistriatus*, *Cerithiopsis vinca*, and *Triphora dupliniana*.

ACKNOWLEDGMENTS

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LITERATURE CITED

ABBOTT, R. T., 1974, American Seashells (2nd Ed.) Van Nostrand Reinhold, New York, 663 p.

BLACKWELDER, B. W., 1981a, Stratigraphy of upper Pliocene and lower Pleistocene marine and estuarine deposits of northeastern North Carolina and southeastern Virginia: U.S. Geol. Survey, Bull. 1502-B, 16 p.

BLACKWELDER, B. W., 1981b, Late Cenozoic marine deposition in the United States Atlantic Coastal Plain related to tectonism and global climate: Palaeogeogr., Palaeoclimat., Palaeoecol., v. 34, p. 87-114.

BLACKWELDER, B. W., 1981c, Late Cenozoic stages and molluscan zones of the U.S. middle Atlantic Coastal Plain: Paleont. Soc. Memoir 12, 34 p.

CRONIN, T. M., L. M. BYBELL, R. Z. POORE, B. W. BLACKWELDER, J. C. LIDDICOAT, and J. E. HAZEL, 1984, Age and correlation of emerged Pliocene and Pleistocene deposits, U.S. Atlantic Coastal Plain: Palaeogeogr., Palaeoclimat., Palaeoecol., v. 47, p. 21-51.

PLATE 1

Figures

1. *Crepidula fornicata* (Linné, 1758). Interior view, female or sexually transitional shell, 38 mm in length.
2. *Nassarius albus* (Say, 1826). Height 16 mm.
3. *Anachis lafresnayi* (Fischer and Bernardi, 1856) var. Height 19 mm.
4. *Urosalpinx cinerea* (Say, 1822). Height 16 mm.
5. *Boonea seminuda* (C. B. Adams, 1837). Height 11 mm.
6. *Melanella conoidea* (Kurtz and Stimpson, 1851). Height 9 mm.
7. *Anachis obesa* (C. B. Adams, 1845). Height 11 mm.
8. *Crepidula plana* Say, 1822. Interior view, 24 mm in length.
9. *Anadara aequicostata* (Conrad, 1845). Interior of right valve, length 54 mm.
10. *Nuculana acuta* (Conrad, 1831). Interior of left valve, length 11 mm.
11. *Noetia limula* (Conrad, 1832). Exterior of left valve, length 60 mm.
12. *Sphenia* sp. Exterior of broken right valve, length 10 mm.
13. *Mercenaria permagna* (Conrad, 1838). Exterior of right valve, length 100 mm.
14. *Mulina lateralis* (Say, 1822). Interior of left valve, length 15 mm.
15. *Abra aequalis* (Say, 1822). Exterior of left valve, length 18 mm.
16. *Ostrea sculpturata* Conrad, 1840. Exterior or right valve, length 79 mm.
17. *Corbula conradi* Gardner, 1943. Interior of right valve, length 13 mm.
18. *Cyclocolposa perforata* (Canu and Bassler, 1923). Field of view is about 4 mm wide.
19. *Spathipora* (small) and *Polydora* (large) borings. Field about 3 mm wide.
20. *Balanus neusensis* (Zullo and Miller, 1986). Cluster length 57 mm, height 32 mm.
21. ?*Cliona* borings in *Noetia* shell. Individual openings are approximately 1 mm in diameter.

PLATE 1

DUBAR, J. R., and J. F. HOWARD, 1969, Paleoecology of the James City Formation (Plio-Pleistocene?) Neuse River estuary, North Carolina: Geol. Soc. Amer., Abstracts with Programs, part 4, p. 20.

DUBAR, J. R., and J. R. SOLLIDAY, 1963, Stratigraphy of the Neogene deposits, lower Neuse Estuary, North Carolina: Southeast. Geol., v. 4, p. 213-233.

DUBAR, J. R., J. R. SOLLIDAY, and J. F. HOWARD, 1974, Stratigraphy and morphology of Neogene deposits, Neuse River estuary, North Carolina, *in* R. Q. OAKS, JR. and J. R. DUBAR (eds.), Post-Miocene Stratigraphy, Central and Southern Atlantic Coastal Plain, Utah State Univ. Press, Logan, p. 102-122.

FALLAW, W., and W. H. WHEELER, 1969, Marine fossiliferous Pleistocene deposits in southeastern North Carolina: Southeast. Geol., v. 10, p. 35-54.

GARDNER, J., 1943, Mollusca from the Miocene and lower Pliocene of Virginia and North Carolina. Part 1. Pelecypoda: U.S. Geol. Survey, Prof. Paper 199-A, 178 p.

GARDNER, J., 1948, Mollusca from the Miocene and lower Pliocene of Virginia and North Carolina. Part 2. Scaphopoda and Gastropoda: U.S. Geol. Survey, Prof. Paper 199-B, 310 p.

MCCARTAN, L., J. P. OWENS, B. W. BLACKWELDER, B. J. SZABO, D. F. MITTERER, and J. F. WEHMILLER, 1982, Comparison of amino acid racemization geochronometry with lithostratigraphy, biostratigraphy, uranium-series coral dating, and magnetostratigraphy in the Atlantic Coastal Plain of the southeastern United States: Quat. Res., v. 18, p. 337-359.

MILLER, W., III, 1985, The Flanner Beach Formation (middle Pleistocene) in eastern North Carolina: Tulane Stud. Geol. Paleont. v. 18, p. 93-122.

MILLER, W., III, 1986a, Paleoecology of benthic community replacement: Lethaia, v. 19, p. 225-231.

MILLER, W., III, 1986b, The rise and fall of local ecosystems: toward a theory of community replacement: North Amer. Paleont. Conv. IV, Abstracts with Programs, A32.

MILLER, W., III, and J. R. DUBAR, 1988, Community replacement of a Pleistocene *Crepidula* biostrome: Lethaia, v. 21, p. 67-78.

OLSSON, A. A., and A. HARBISON, 1953, Pliocene Mollusca of Southern Florida: Acad. Nat. Sci. Philadelphia, Monograph 8, 457 p.

RAY, C. E. (ed.), 1983, Geology and paleontology of the Lee Creek mine, North Carolina, I: Smithson. Contrib. Paleobiol. 53, 529 p.

SNYDER, S. W., and M. R. KATROSH, 1979, An exposure of marginal marine Pleistocene sediments, Pitt County, North Carolina: Southeast. Geol., v. 20, p. 247-259.

STANLEY, S. M., 1986, Anatomy of a regional mass extinction: Plio-Pleistocene decimation of the Western Atlantic bivalve fauna: Palaios, v. 1, p. 17-36.

TOUMEY, M., and F. S. HOLMES, 1857, Pleiocene Fossils of South-Carolina, James and Williams Printers, Charleston, 152 p.

WALLER, T. R., 1969, The evolution of the *Argopecten gibbus* stock (Mollusca: Bivalvia), with emphasis on the Tertiary and Quaternary species of eastern North America: Paleont. Soc. Memoir 3, 125 p.

WOODS, D. M., 1987, The paleoecology of *Crepidula* (Gastropoda) beds, James City Formation (Pleistocene), North Carolina: Unpubl. M. S. thesis, Tulane Univ., 119 p.

ZULLO, V. A., and W. MILLER, III, 1986, Barnacles (Cirripedia: Balanidae) from the lower Pleistocene James City Formation, North Carolina, with the description of a new species of *Balanus* da Costa: Proc. Biol. Soc. Washington, v. 99, p. 717-730.

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ON A NEW SPECIES OF *VENERICARDIA* FROM THE LOWER EOCENE IN NORTHEASTERN MEXICO (DIFUNTA GROUP)

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I. ABSTRACT

Venericardia (Venericor) elongata, n. sp., from the lower Eocene of northeastern Mexico, associated with *Venericardia (Venericor) planicosta* and *Turritella mortoni postmortoni*, is the first fossil described from the Adjuntas Formation.

The paleoenvironmental analysis suggests that conditions of geographic isolation were propitious for the speciation of this locally distributed species.

II. INTRODUCTION

The Difunta Group represents an Upper Cretaceous-Tertiary transition of terrigenous sediments that were deposited in two sedimentary basins in northeastern Mexico, known as the Parras and La Popa basins (McBride *et al.*, 1974). The group is subdivided into 13 formations, with the proposed stratigraphic range for the Difunta Group being Campanian to Paleocene. Recent studies have revealed the existence of lower Eocene beds (Ypresian or Wilcox) in the Adjuntas Formation of the La Popa basin (Vega and Perrilliat, 1986).

The geographic distribution of the Difunta Group extends to east of Torreón, Coahuila, north of Saltillo, Coahuila, northwest of Monterrey, Nuevo Leon, and southeast of Monclova, Coahuila. The La Popa basin is located between 25°55′-26°40′ N lat. and 100°40′-101°10′ W long. (Fig. 1).

Several paleontological studies have been made on units in the Difunta Group. Imlay (1937) described some molluscan species from the Senonian of Laguna de Mayrán, Coahuila, and Wolleben (1977) reported 52 invertebrate species collected in formations of the Difunta Group. Of these species, the youngest are the Paleocene nautiloids *Cimomia haltomi* (Aldrich) and *Hercoglossa* sp. aff. *H. fricator* (Beck), found in the Rancho Nuevo Formation (Parras basin), considered as the uppermost unit of the Difunta Group. A Maastrichtian age was assigned to the Adjuntas Formation (McBride *et al.*, 1974; Wolleben, 1977; Laudon, 1984), but Eocene molluscan species have been reported in recent studies (Vega and Perrilliat, 1986). The marine Eocene deposits from the La Popa basin is the westernmost report of rocks of this age in northeastern México. The eocenic strata of northeastern Nuevo León contain venericardian species such as *Venericardia (Venericor) cacamai* Gardner and Bowles, *V. (V.) zapatai* Gardner and Bowles, *V. (V.) densata malinchae* Gardner and Bowles, *V. (V.) hatcheplata* Gardner and Bowles, *V. (V.) diga* Gardner and Bowles. *Venericardia (V.) densata* Conrad was reported from northern Tamaulipas by Gardner and Bowles (1939) and Perrilliat (1963). None of these species was found in the Adjuntas Formation, which, however, contains abundant specimens of *V. (V.) planicosta*, widely distributed in the lower Eocene strata of the world.

The material here described was found in outcrops of the Adjuntas Formation, in an anticlinal structure known regionally as "Cerro La Carroza" (Fig. 2). The Adjuntas Formation is underlain by the Potrerillos Formation. The lower three members of the Potrerillos are Maastrichtian in age, while the upper two belong to the Paleocene (Vega, 1987a; 1987b). The Adjuntas Formation is overlain by the Viento and Carroza formations (Fig. 3). The scarcity of fossils in these formations make dating difficult.

The type section of the Adjuntas Formation is located in a stream east of Cerro la Carroza, with an approximate thickness of 260 m (McBride *et al.*, 1974). The lithology is chiefly red beds, but also present are green, yellow, and gray beds. The gray strata are present at the base and top of the formation and contain an abundant but not diverse macro-invertebrate fauna. *Venericardia planicosta* Lamarck and *Turritella mortoni postmortoni* Conrad are present as part of this fauna (Vega and Perrilliat, in press). These two species are

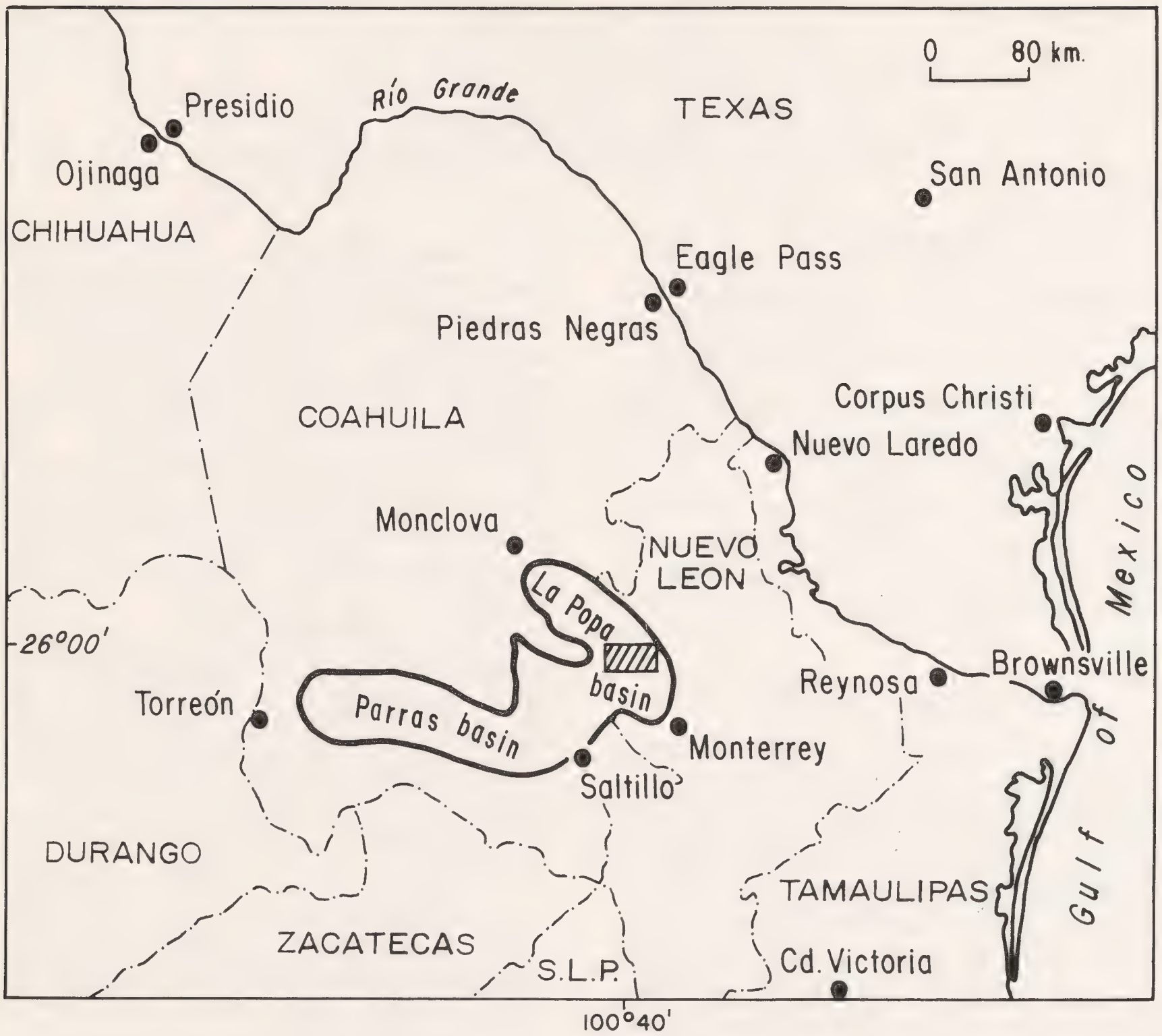

Figure 1. Location map of the Parras and La Popa basins (Difunta Group) in northeastern Mexico. Study area is diagonally ruled.

index fossils for the Ypresian (lower Eocene) deposits of the Atlantic and Gulf Coastal Plain (Shimer and Shrock, 1944). Associated with these molluscan species are a few ostreids and the bivalve here described. The green beds at the base of the formation contain nodules not greater than 20 cm in diameter and many gastropods, which will be the object of another report.

III. PALEOENVIRONMENT

The red, green, and yellow beds of the Difunta Group have been interpreted as deltaic plain deposits, represented as mudstones, siltstones, and, in minor amounts, sandstones. These sediments were deposited in a subhumid-semiarid climate, with seasonal episodes of dry conditions (McBride, 1974). The color diversity of the rocks is attributed to the following factors: 1) content of Fe and organic matter in the sediments; 2) post-depositional physio-chemical events; and 3) variations of the phreatic level and climatic conditions. Gray beds owe their color to a greater organic matter content and minor concentration of iron. These rocks represent pro-deltaic and, in lesser amounts, deltaic-plain facies. The red beds suggest oxydation of the sediments, which were exposed seasonally to dry conditions, while the green beds owe their color to a high concentration of illite and chlorite, and to reducing conditions below the phreatic level. For the green beds associated with channel-fill sandstones, a percolation of reducing water formed by accumulation and putrefaction of organic matter (fairly vegetal) in the channel water is proposed (McBride, 1974).

The abundance of infaunal deposit-feeder gastropods (cerithids) in the green mudstones suggests a brackish water environment with a high content of organic

Figure 2. Location of Cerro La Carroza in La Popa basin. Type locality is at the eastern side of the hill.

matter. The red and green beds were deposited in lagoons, estuaries and swamps, which must have contained brackish and fresh water. Shell fragments and mollusca were found in the gray beds. The molluscan species (*V. planicosta* and *T. mortoni postmortoni*) are characteristic of shallow marine environments (Woods, 1922; Park, 1968). Thus, the sedimentary cycles of the Adjuntas Formation include deltaic plain (red, green, and yellow beds), and inner shelf facies (gray beds). The environmental changes were caused by subsidence episodes, followed by deltaic progradations in which the red beds were oxydized.

Deltaic systems are characterized by a wide diversity of mixed environments, such as lagoons, estuaries, swamps and inner shelf. These environments are adequate for species with ecological restrictions that could augment speciation events, by means of geographic isolation. Park (1968, p. 978-979) proposed that the *Venericor* species seem to comprise a relatively homogeneous ecologic group, with a single optimum environment, characterized by shallow water and low-sedimentation rates. The sedimentary cycles of the Adjuntas Formation include transgression events in which the Nuevo León and other molluscan species proliferated, as the sedimentation rate of the inner shelf was very low. The morphological and paleoecological affinities between *Venericor* and *Glyptoactis* (Heaslip, 1963, Park, 1968), suggest that the Nuevo León form could be an intermediate one between these two subgenera.

IV. ACKNOWLEDGMENTS

We are grateful to E. H. Vokes (Tulane University) for her valuable comments and critical review of the manuscript.

V. SYSTEMATIC DESCRIPTION

Phylum MOLLUSCA
Class BIVALVIA

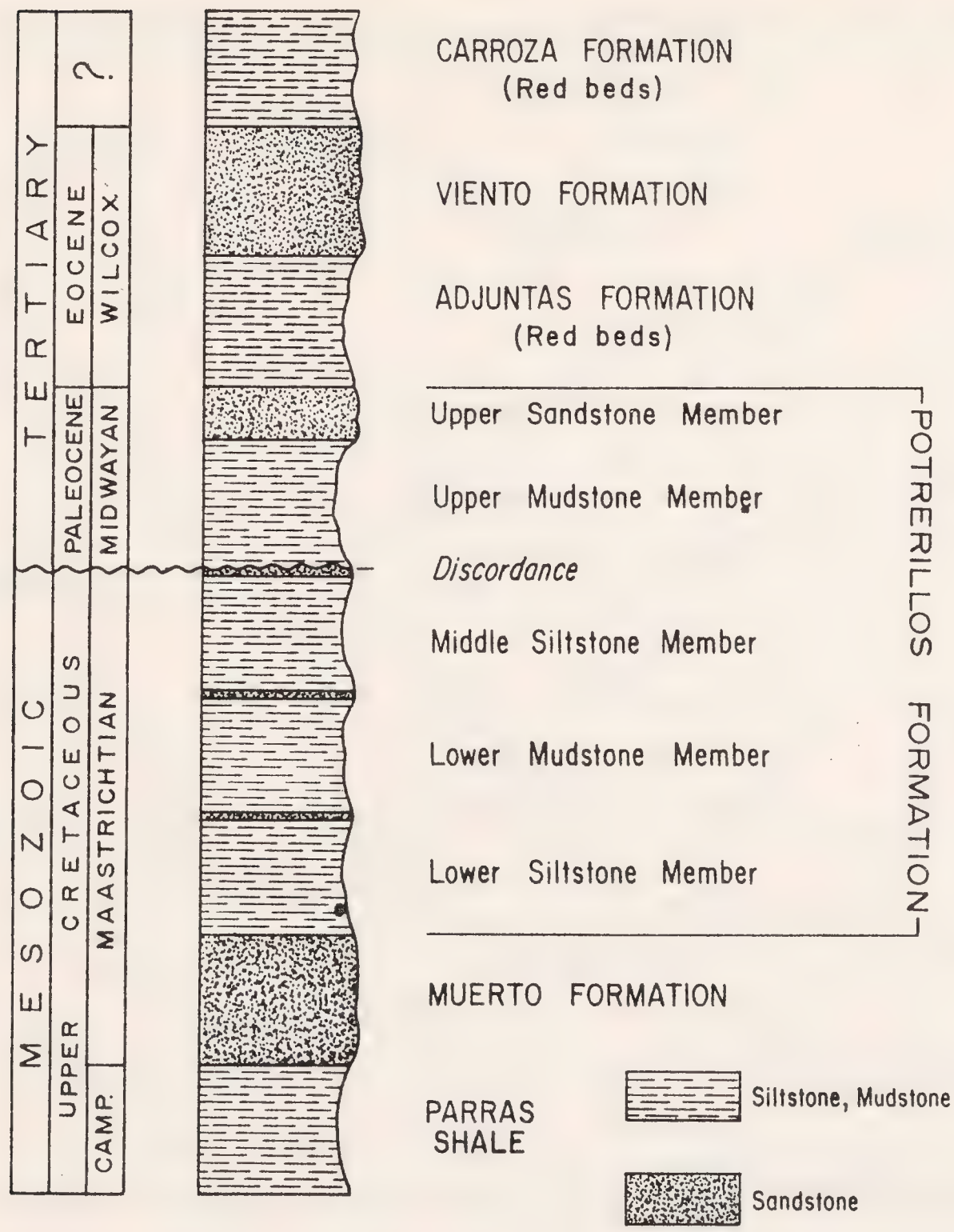

Figure 3. Composite stratigraphic column from the La Popa basin in Nuevo León State, México, showing the stratigraphic position of the Adjuntas Formation.

Order HETERODONTA
Superfamily CARDITACEA Fleming, 1820
Family CARDITIDAE Fleming, 1820
Genus VENERICARDIA Lamarck, 1801

Venericardia LAMARCK, 1801, Systéme des animaux sans vertèbres, p. 123.

Type species: *Venericardia imbricata* Lamarck = *Venus imbricata* Gmelin; Grignon, Seine et Oise, France; Lutetian, middle Eocene; by subsequent designation, Schmidt, 1818.

Subgenus VENERICOR Stewart, 1930

Venericor STEWART, 1930, Acad. Nat. Sci. Philadelphia, Spec. Pub. 3, p. 153.

Type species: *Venericardia planicosta* Lamarck; Paris Basin, Eocene; by original designation.

VENERICARDIA (VENERICOR) ELONGATA
Vega and Perrilliat, n. sp.
Figure 4

Description: Shell equivalve, inequilateral, subtrapezoidal in shape. Valves thick, inflated. Umbones prominent, well rounded, beaks in contact, prosogyrate, situated 1/3 the length of the shell from the anterior extremity. Anterior margin sharply rounded, except in the dorsal portion, where it is almost flat. Anteroventral region broadly rounded, continuous with an almost straight ventral margin, which ends in a strong angle at the posteroventral region. Posterior margin inflated and prominent. A sharply defined angular umbonal ridge, extending from the beak obliquely downward and backward to the lower posterior extremity, passing between the 19th and 20th ribs; the ridge more prominent at the middle height of the shell. Lunule deep, very small. Escutcheon large, well defined. Twenty-eight radial ribs in each valve, 20 on the medio-anterior portion and eight on the posterior. Crests of the ribs broad and flat, quadrangular in transverse section, crossed by concentric grooves to the ventral margin. Interspaces "U" shaped, crossed by numerous undulate lamellae near the ventral region; these lamellae

less conspicuous at the crest of the ribs. Interspaces well defined and representing 1/3 the width of the ribs at the ventral margin. The morphology of the hinge unknown, as all the specimens are articulated; however, the section of one specimen proved that it is clearly heterodont.

The height/length ratio of the holotype is 1.280, while the paratype is 1.285. Similar morphological characteristics, and the almost identical H/L ratio suggests that our specimens belong to the same species.

Holotype: IGM 4736; length 54.3 mm, height 42.4 mm, width 34.9 mm.

Type locality: IGM-1973, Adjuntas Formation, outcrop at the eastern side of Cerro La Carroza, approximately 16 km southeast of the town of San José de La Popa, northwest of Monterrey, Nuevo León, México.

Paratype: IGM 4737; length 64.4 mm, height 50.1 mm, width 40.5 mm.

Discussion: The Nuevo León specimens are similar to the *Venericardia planicosta* group as the ribs are broad and flat. No form of the *alticostata* group is similar to our specimens, although some authors suggest that the alticostate forms could have given rise to *Venericor* forms (Heaslip, 1963). Some members of the *planicosta* group are similar to the Adjuntas specimens in number and shape of the ribs. *Venericardia (Venericor) densata* Conrad is a extremely abundant species from the middle Eocene in Alabama, Mississippi, Louisiana, Texas, and Tamaulipas. It has an oval shape, with 26-27 ribs that are cancellate toward the ventral margin. *Venericardia (V.) tonoensis* Rutsch, 1936, has a more oval shape and the interspaces are less broad. This species is found in the middle Eocene of Panama. *Venericardia (V.) pacifica* Olsson, 1928, has a semicircular shape, 28 ribs, which are narrower than those of the Adjuntas specimens, and its interspaces are also broader. This form belongs to the middle Eocene of Peru. *Venericardia (V.) turneri* Gardner and Bowles, 1939, has the umbones more displaced toward the anterior portion, is quadrate in shape, and has 28 ribs with

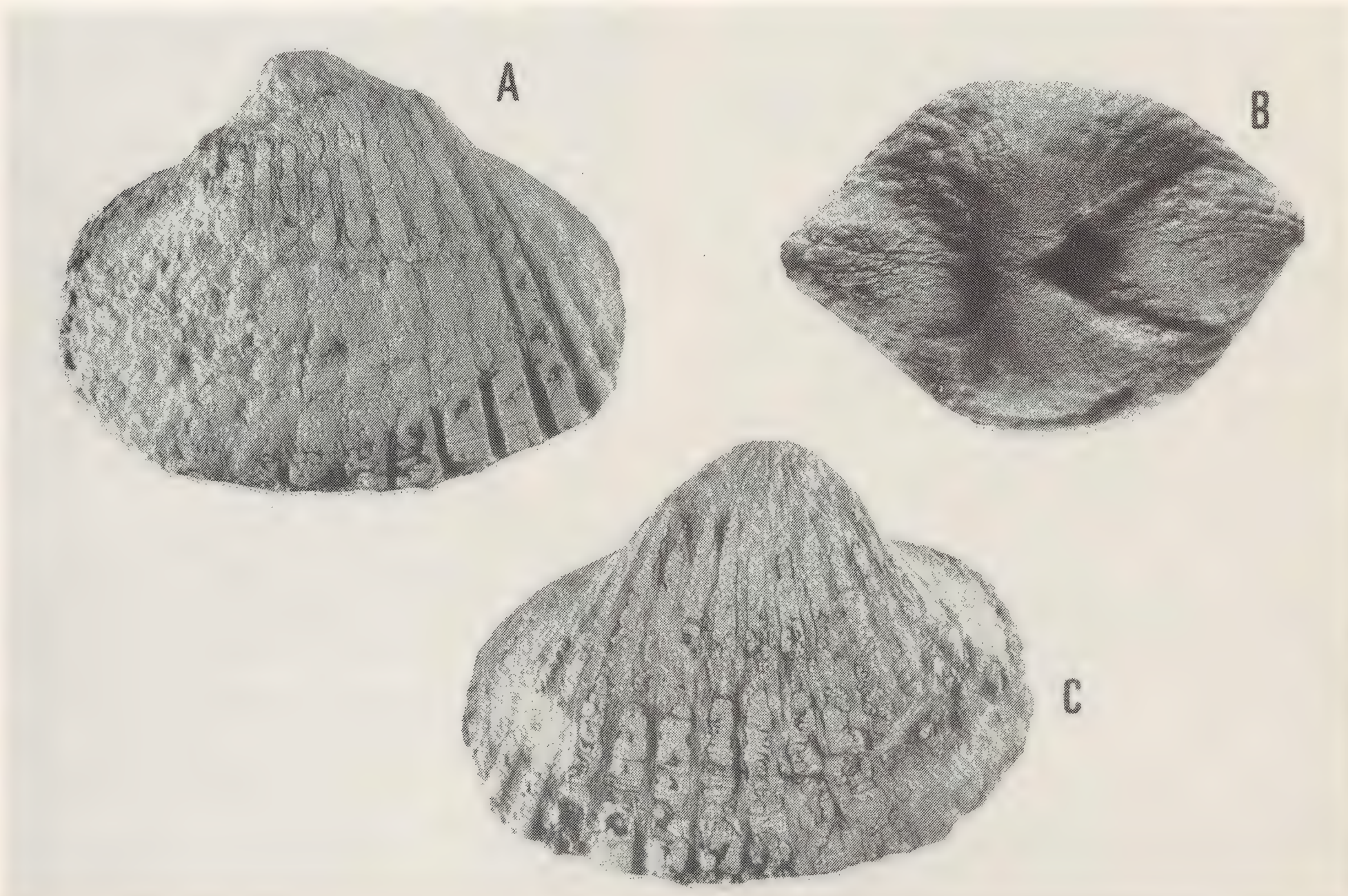

Figure 4. *Venericardia (Venericor) elongata* Vega and Perrilliat, n. sp. Holotype, IGM 4736; Length 54.3 mm, height 42.4 mm, width 34.9 mm (X 1). A, left valve; B, right valve; C, dorsal view. Locality: Adjuntas Formation, eastern side of Cerro La Carroza, approximately 16 mk southeast of San José de La Popa, Nuevo León, México.

narrow interspaces. It has been reported from the middle Eocene of Alabama. *Venericardia (V.) ascia* Rogers and Rogers, 1839, from the lower Eocene of Maryland and Virginia, has a suboval shape with 27-28 low ribs and narrow interspaces. *Venericardia (V.) claviger* Gardner and Bowles, 1939, has 27 ribs with deep, very narrow interspaces. The shape of this form is trigonal, with the posterior margin obtusely truncated. It has been reported from the middle Eocene of Alabama and South Carolina. *Venericardia (V.) mediaplata* Gardner and Bowles, 1939, from the lower Eocene of Georgia, Alabama, Mississippi, Tennessee, and Texas has a semioval shape, with 29 ribs separated by lineal interspaces. The subquadrate shape of *V. (V.) nanaplata nanna* Gardner and Bowles, 1939, and its obtusely truncated posterior margin, makes it different from the Adjuntas specimens. It also has 29 ribs separated by broad interspaces and is smaller than our specimens. That subspecies has been reported from the lower Eocene of Alabama. The subspecies *V. (V.) densata pendletonensis* Gardner and Bowles, 1939, is an excellent index fossil to the lower Claiborne of Texas. It has an oval-trigonal shape, 28-29 ribs, separated by lineal interspaces.

VI. LITERATURE CITED

GARDNER, J. A., and E. BOWLES, 1939, The *Venericardia planicosta* group in the Gulf Province: U. S. Geol. Surv., Prof. Paper 189-F, p. 143-215, pls. 33-46.

HEASLIP, W. G., 1963, Planicostate trend among alticostate venericards of North America: Geol. Soc. Amer., Spec. Paper 73, p. 168-169.

HEASLIP, W. G., 1968, Cenozoic evolution of the alticostate venericards in Gulf and East Coastal North America: Palaeontographica Americana, v. 6, no. 39, p. 55-135, pls. 20-29.

IMLAY, R. W., 1937, Stratigraphy and paleontology of the Upper Cretaceous beds along the eastern side of Laguna de Mayran, Coahuila, Mexico: Geol. Soc. Amer., Bull.,. v. 48, no. 12, p. 1785-1872, 26 pls.

LAUDON, R. C., 1984, Evaporite diapirs in the La Popa basin, Nuevo León, México: Geol. Soc. Amer., Bull., v. 95, p. 1219-1225.

MCBRIDE, E. F., 1974, Significance of color in red, green, purple, olive, brown and gray beds of Difunta Group, Northeastern Mexico: Jour. Sed. Petrol., v. 44, no. 3, p. 760-773.

MCBRIDE, E. F., A. E. WEIDIE, J. A. WOLLEBEN, and R. C. LAUDON, 1974, Stratigraphy and structure of the Parras and La Popa Basins, Northeastern Mexico: Geol. Soc. Amer., Bull., v. 84, no. 10, p. 1603-1622.

OLSSON, A. A., 1928, Contributions to the Tertiary Paleontology of Northern Peru: Part 1, Eocene Mollusca and Brachiopoda: Bulls. Amer. Paleontology, v. 14, no. 52, p. 1-154, pls. 1-26.

PARK, R. A., 1968, Paleoecology of *Venericardia sensu lato* (Pelecypoda) in the Atlantic and Gulf Coastal Province: an application of paleosynecologic methods: Jour. Paleontology, v. 42, no. 4, p. 955-986, 29 text figs.

PERRILLIAT, M. C., 1963, Moluscos del Terciario Inferior del Noreste de México: Paleontologia Mexicana, no. 19, 26 p., 15 pls., 2 text figures.

ROGERS, W. B., and H. D. ROGERS, 1839, Contributions to the geology of the Tertiary formations of Virginia: Amer. Phil. Soc., Trans., (N.S.) v. 6, Art. 14, p. 371-377, pls. 28-30.

RUTSCH, R., 1936, Beiträge zur Kenntnis tropisch-amerikanischer Tertiärmollusken. IV. Die stratigraphische Bedeutung der *Venericardia planicosta* und ihrer Venvandten: Eclogae Geol. Helv., v. 29, no. 1, p. 151-186, pl. 16.

SHIMER, H. W., and R. R. SHROCK, 1944, Index fossils of North America. John Wiley and Sons, London, 837 p.

VEGA, F. J., 1987a, Importancia geológico-estratigráfica de la transición Cretácico Superior-Terciario en la Cuenca de La Popa (Grupo Difunta), Nuevo León, México: México, Univ. Autón. Nuevo León, Fac. Cienc. Tierra, Actas, v. 2, p. 107-110.

VEGA, F. J., 1987b, Contriburiones a la estratigrafia del Grupo Difunta en la Cuenca de La Popa, Coahuila y Nuevo León: *in* Segundo Simposio sobre Geologia Regional, Univ. Nacl. Autón. México, Inst. Geologia, Programa y Resúmenes, p. 15-17.

VEGA, F. J., and M. C. PERRILLIAT, 1986, El Grupo Difunta y la presencia del Terciario marino en la Cuenca de La Popa, Nuevo León: *in,* Primer Simposio sobre Geología Regional, Univ. Nacl. Autón. México, Inst. Geología, Programa y Resúmenes, p. 29-30.

VEGA, F. J., and M. C. PERRILLIAT, *in press,* Moluscos del Maastrichtiano de la Sierra El Antrisco, Nuevo León, México: Paleontologia Mexicana, no. 55.

WOLLEBEN, J. A., 1977, Paleontology of the Difunta Group (Upper Cretaceous-Tertiary) in Northern Mexico: Jour. Paleontology, v. 51, no. 2, p. 373-398, 3 pls.

WOODS, H., 1922, Mollusca from the Eocene and Miocene deposits of Peru, *in:* BOSWORTH, Geology and Paleontology in the northwest part of Peru, p. 51-113, pls. 1-20.

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MURICIDAE (MOLLUSCA:GASTROPODA) OF THE ANGOSTURA FORMATION, NORTHWESTERN ECUADOR

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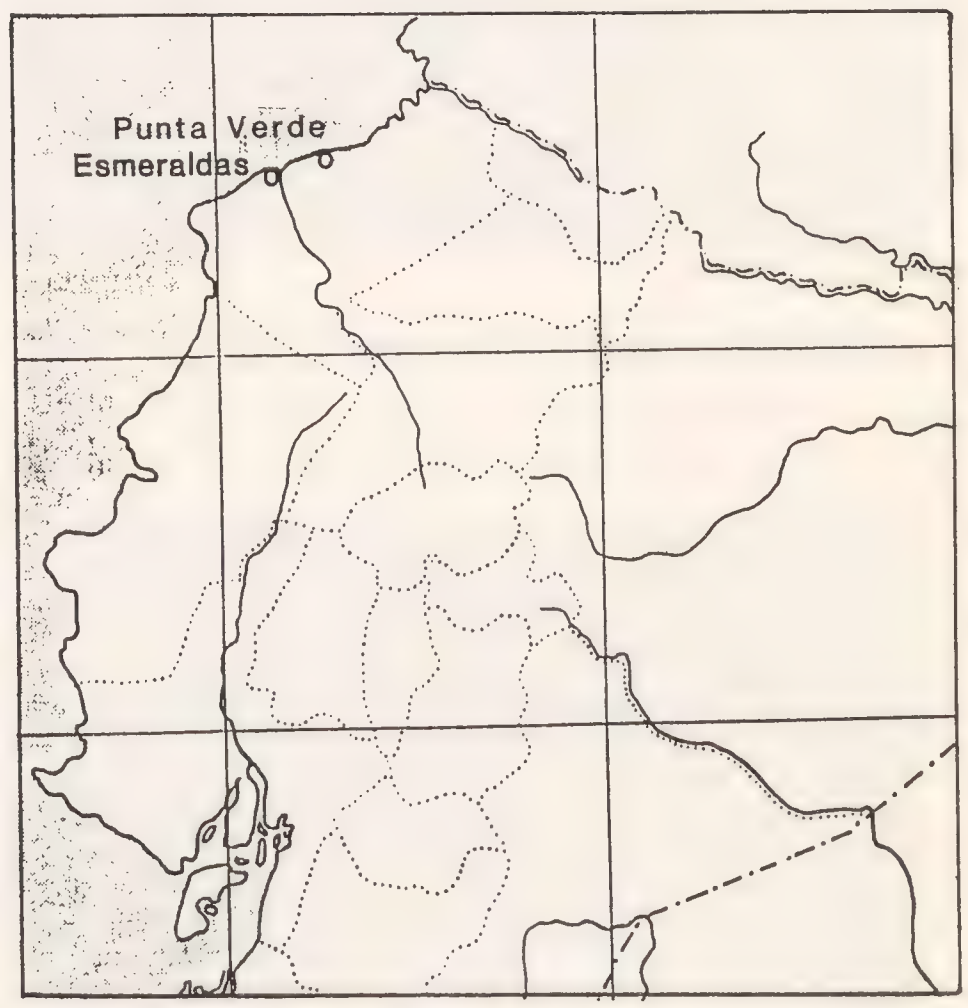
I. ABSTRACT

The muricid fauna of the Late Miocene Angostura Formation, northwestern Ecuador, includes two species previously known from the Gatun Formation of Panama, the Esmeraldas Beds of Ecuador, and other localities in the Caribbean Tertiary. There are also two new species described herein. One, *Eupleura olssoni,* is most closely related to an unnamed Gatun species; the second, *Ceratostoma (Microrhytis) ecuadorium,* is most closely related to *C. (M.) pecki* (Emerson), described from the Atlantic side of the Isthmus of Tehuantepec, Mexico. Thus, the muricid fauna has a closer affinity with the Tertiary beds of the western Atlantic than with the Recent fauna of the eastern Pacific.



Text-figure 1. Map of northwestern Ecuador, showing study area.

II. INTRODUCTION

Olsson (1964, p. 8) noted that the Miocene section along the Río Santiago, in northwestern Ecuador, begins with the Angostura Formation, stating: "The lowest part of the Miocene sequence is formed by the Angostura formation, named from the Angostura gorge, and consists predominantly of coarse sandstones and beds of conglomerates, about 150 meters in thickness." He added that, although the Angostura beds are largely barren, in places there are lenses of finely preserved fossils, the principal localities in the area being the so-called "Cueva de Angostura," on the Río Santiago, and Telembi, an Indian village on the Río Cayapas, which parallels the Río Santiago to the west. An attempt by the author to re-collect these two

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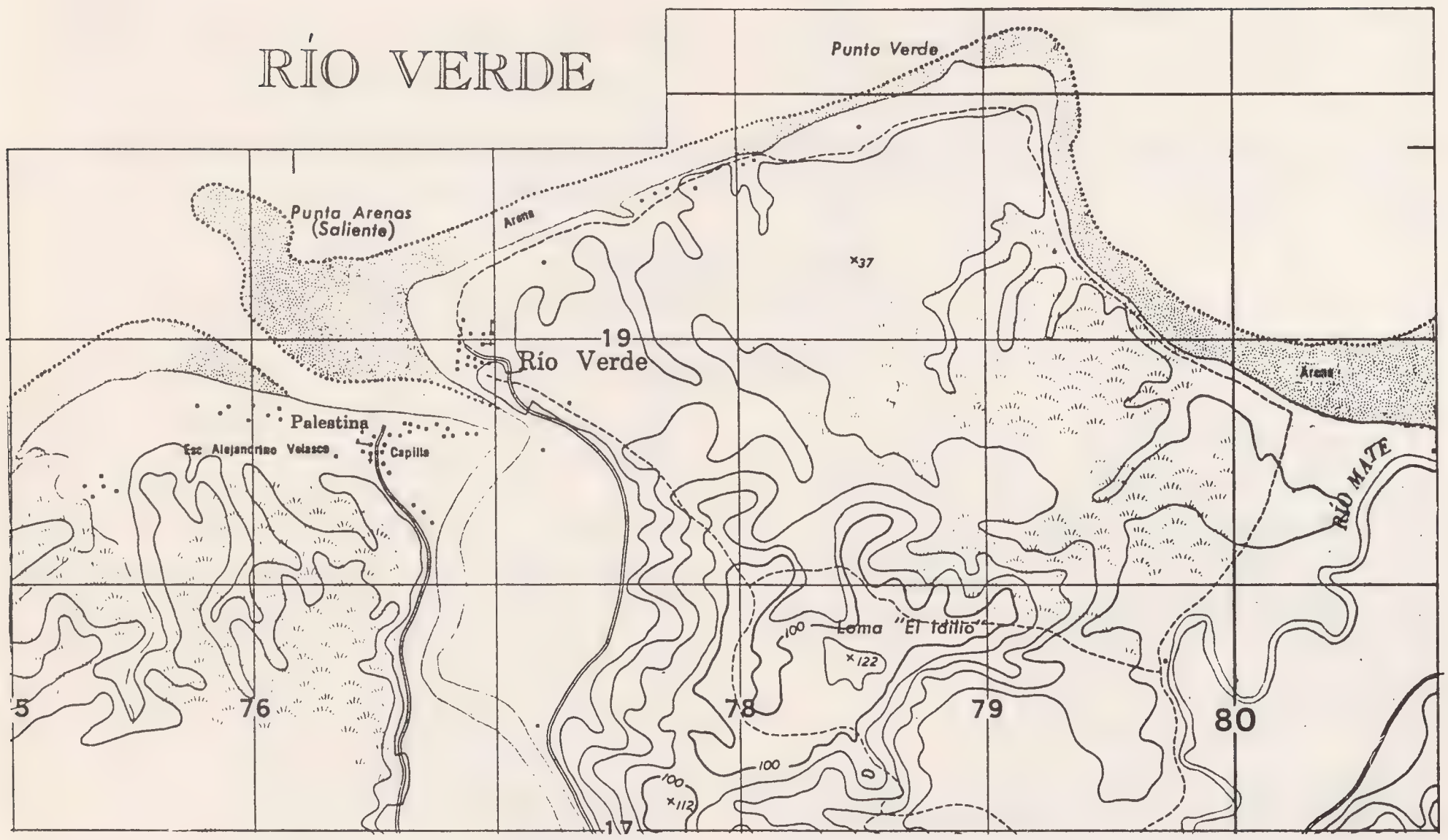


Text-figure 2. Map of Río Verde area, Province of Esmeraldas, Ecuador.

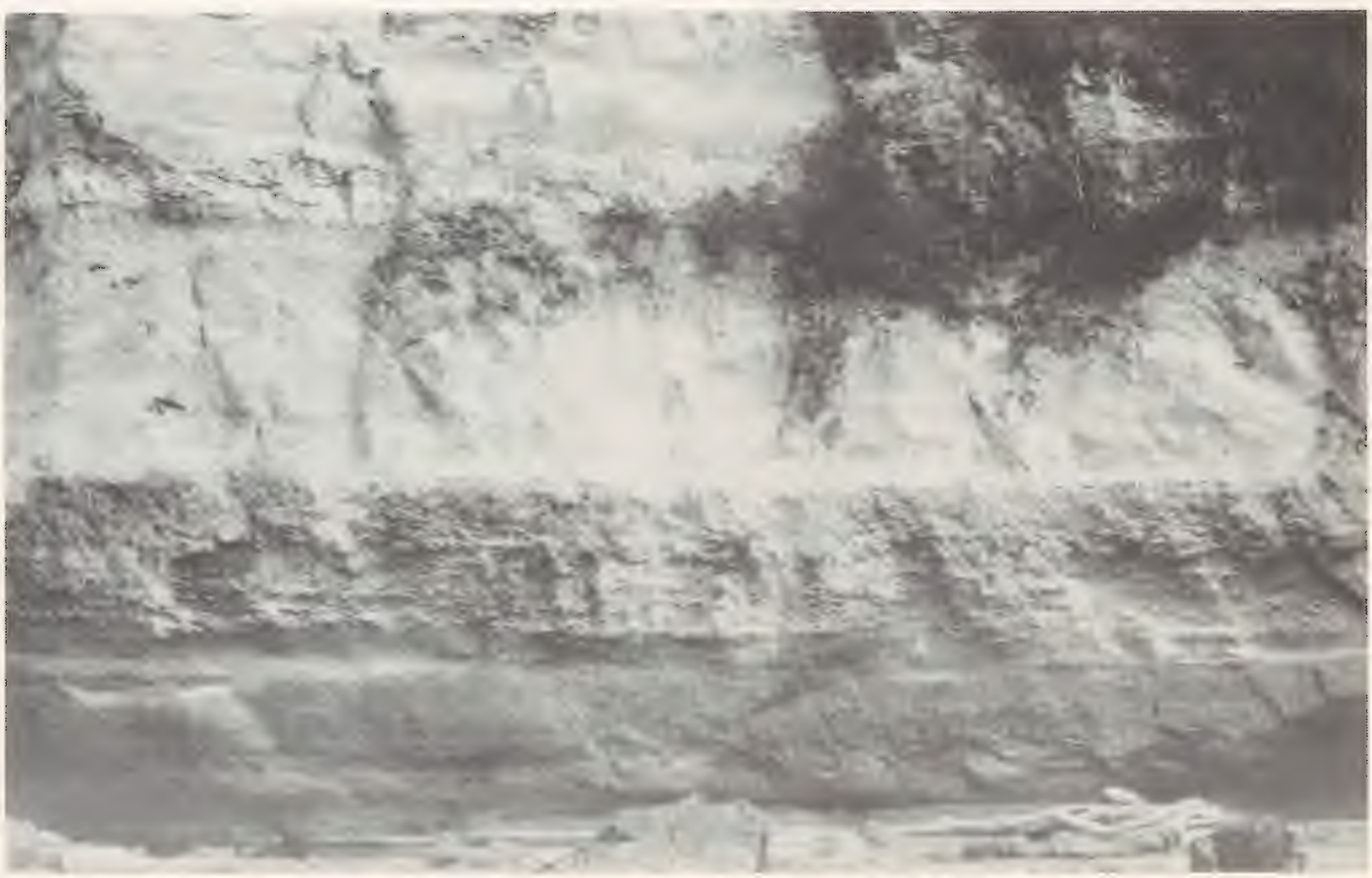
localities was foiled by the caprices of nature – water too low on the Río Santiago, and, at the same time, too high on the Río Cayapas.

Fortunately, there is another excellent section of the Angostura Formation exposed along the coast east of Río Verde, a fishing village at the mouth of the Río Verde, about 30 km east of the city of Esmeraldas (see text-figs. 1, 2). There a magnificent section is exposed (text-figs. 3, 4), which, according to Whittaker (1988, p. 10), consists of the Middle Miocene Viche Formation (planctic foraminiferal zone N 12) at the base and the Late Miocene Lower Onzole Formation (N 16) at the top, with the Angostura Formation in between (text-fig. 5). Whittaker describes the Angostura Formation at this location as resting "with a sharp conformable contact on the Viche mudstones," but the contact is markedly eroded (text-figs. 6, 7) and is better classified as disconformable.

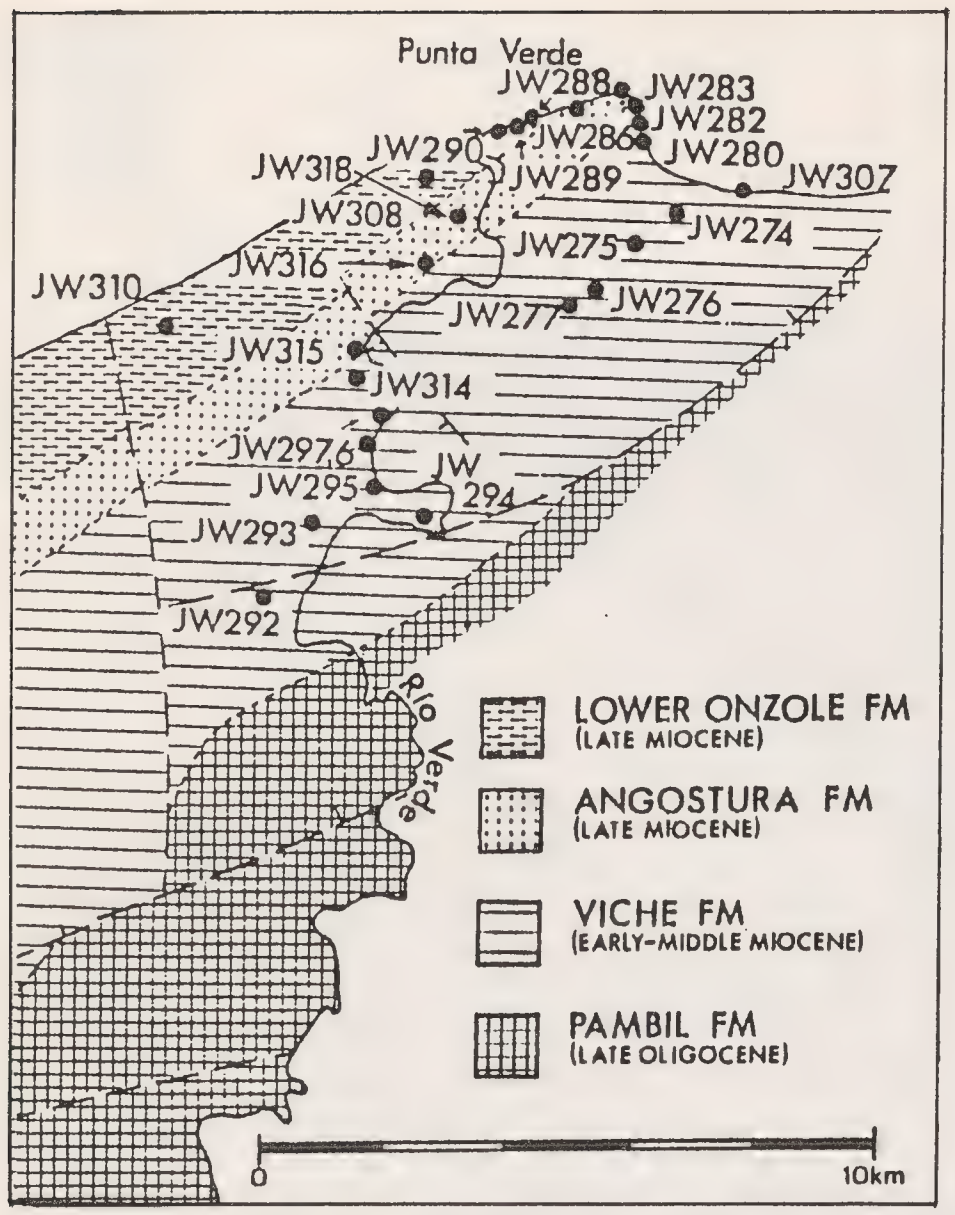
The age of the Angostura Formation is uncertain, as there are no diagnostic planktic foraminifera in these shallow-water beds. However, as the beds of the Lower Onzole Formation, resting immediately above the Angostura at Punta Verde, are dated as latest Miocene (Whittaker, 1988, p. 11), the assumption is that the Angostura Formation is probably Late Miocene in age. If this is the case, then the unit may be slightly older than the Gatun Formation of Panama, with which it was correlated by Olsson (1964, p. 8). This is reflected in the molluscan fauna, which, as Olsson noted, is closely related to the Gatun and "many Angostura species described as new differ from related Gatun species only in small particulars."

The reason why the Angostura fauna has such a strong resemblance to that of the Gatun is more a matter of facies than time. The two formations are identical in facies, both being shallow-water, nearshore units. Many of the species, at first glance, seem to be the same as those in the Gatun but, upon closer examination, prove to be, as Olsson noted, slightly different, which should make evolutionary gradualists very happy. Of the four muricid species treated herein, Olsson had two from the Angostura beds at Cueva de Angostura and Telembi: *Haustellum polynematicus* (Brown and Pilsbry), which also occurs in the Gatun Formation, the Esmeraldas beds, and unnamed beds in southern Colombia (see Vokes, 1988, p. 17); and *Eupleura olssoni*, n. sp., which is

Text-figure 3. Sea cliffs, exposed along coast at Punta Verde, Province of Esmeraldas, Ecuador.



Text-figure 4. Section exposed in sea cliffs at Punta Verde. Darker beds at bottom of picture are Angostura Formation; lighter beds at top are Lower Onzole Formation.



Text-figure 5. Geologic map of Río Verde area (from Whittaker, 1988, figure 2; numbers are his collecting sites). Our locality is approximately the same as JW 288.

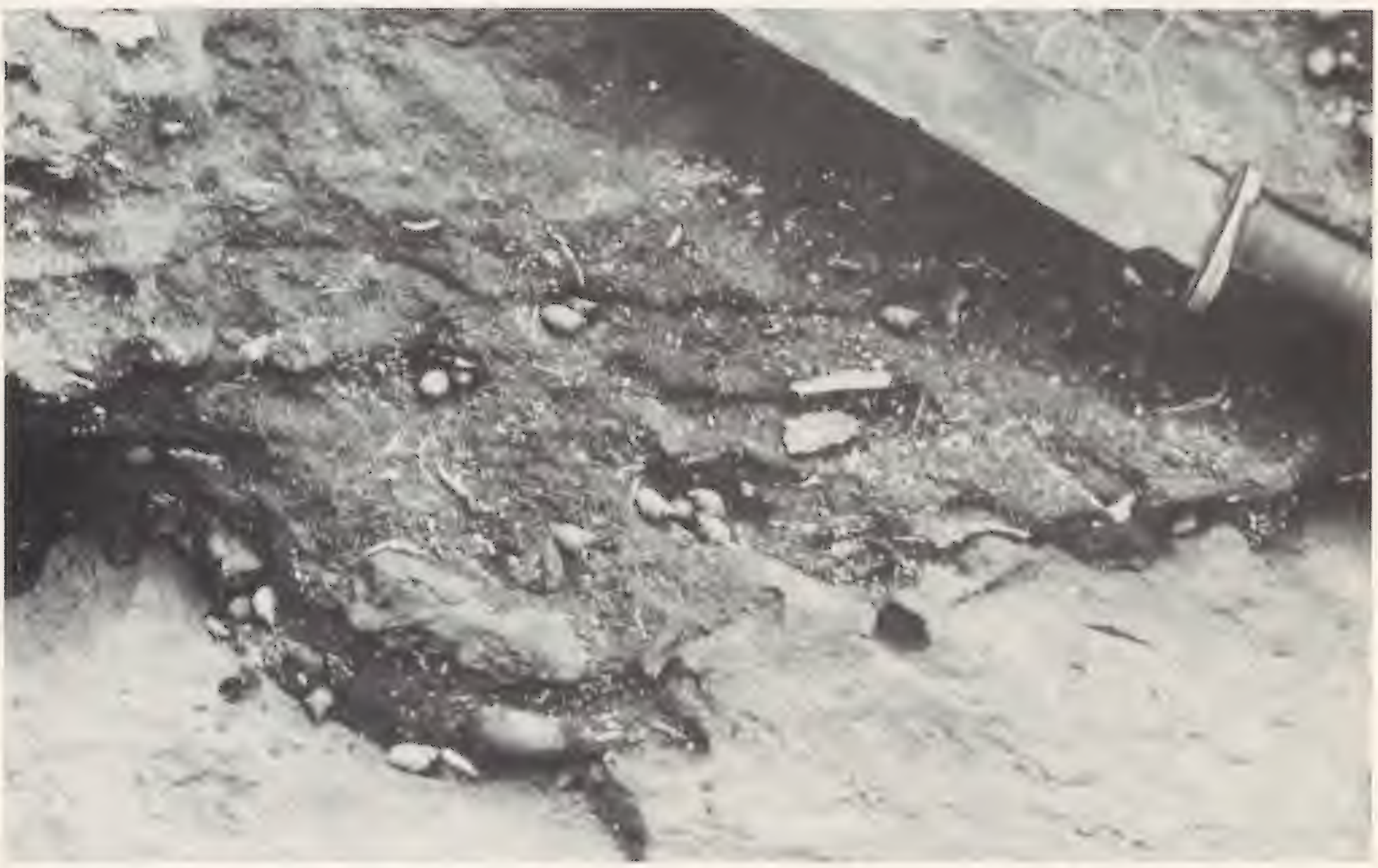
related to another Gatun species (not *E. thompsoni* Woodring, as indicated by Olsson). He also listed *Typhis alatus* Sowerby from the Picaderos [= Onzole] Formation, which overlies the Angostura on the Río Santiago. This long-ranging latter species occurs throughout the Caribbean from the Middle Miocene of the Dominican Republic to the Early Pliocene Gatun Formation. The only other muricid species, described herein as *Ceratostoma (Microrhytis) ecuadorium,* is most closely related to *C. (M.) pecki* (Emerson), described from Middle Miocene (N 13-14) beds in the Isthmus of Tehuantepec, Mexico.

The locality at Punta Verde was originally discovered by Roger Bristow and John Whittaker, of the British Geological Survey and the British Museum (Natural History), Department of Palaeontology, respectively. They told William and Lois Pitt about the locality and, together with Mr. and Mrs. Pitt, my husband and I first visited Punta Verde in 1986. There we found that, as one walks along the beach eastward from the town, the northwesterly dip of the beds gradually exposes the complete section. Initially, the cliffs are composed of an unfossiliferous gray silt, which Whittaker refers to the Lower Onzole Formation. The first (stratigraphically highest) fossiliferous beds consist of a indurated, massive sandstone, containing numerous pectens, sand-dollars, and many specimens of *Ostrea haitensis* Sowerby, 1850, a common fossil throughout the Caribbean. This is underlain by a sandy lens filled with rather chalky pelecypods and gastropods of many species. Beneath this is a non-fossiliferous zone and, finally, at the base of the Angostura Formation, where it rests on the Viche, there is another lens of molluscan fossils. This latter zone is crowded with specimens of *Turritella,* but it is also in this level that the muricid specimens occur. The first time we visited Punta Verde there was a small area with well-preserved fossil mollusks in the wave-cut bench exposed at low tide. However, when we returned in 1988, sand had completely covered this outcrop and we could find no trace of it.

Beneath the Angostura Formation lies the Viche Formation, which has no fossil mollusks in it. The contact is highly irregular, with many burrows extending from the Angostura down into the indurated clay of the Viche beds. The majority of the best-preserved fossils lie just above this contact. The Angostura Formation presumably represents a trangression over the semi-lithified beds of the Viche Formation. The contact with the overlying Onzole Formation is gradational and probably represents the natural deepening of the basin.

The Angostura muricid fauna is rich neither in numbers of species nor in individuals. However, as the oldest fauna in the transgressive sequence that culminates in the rich muricid fauna of the Esmeraldas Beds, it is of interest to see the make-up of the shallow-water facies. In the same area today there are living the descendants of just one of these species, *Eupleura olssoni,* n. sp. No longer is there any species that can be related to *Haustellum polynematicus, Typhis alatus,* or *Ceratostoma (Microrhytis) ecuadorium,* n. sp.

Text-figure 6. Contact of Angostura Formation on older Viche Formation, Punta Verde, Ecuador.



Text-figure 7. Closeup of Viche-Angostura contact, showing irregular contact (most of the gastropods in this photograph are living specimens of *Littorina*, but one can see pebbles and shells near the basal contact of the Angostura Formation).

III. ACKNOWLEDGMENTS

The greatest thanks are extended to both C. Roger Bristow, British Geological Survey, and John E. Whittaker, British Museum (Natural History), Department of Palaeontology, for all the information that they have made available (both published and non-published) concerning the geology of the coast of Ecuador. For the loan of specimens I am grateful to George M. Davis and Elena Benamy, Academy of Natural Sciences, Philadelphia, and Thomas R. Waller and Warren Blow, U. S. National Museum. William and Lois Pitt, of Sacramento, California, have been tireless collectors and cheerful traveling companions, offering all manner of help and moral support in our on-going Ecuadorian paleontological studies.

IV. SYSTEMATIC PALEONTOLOGY

Class GASTROPODA
Order NEOGASTROPODA
Superfamily MURICACEA
Family MURICIDAE Rafinesque, 1815
Subfamily MURICINAE Rafinesque, 1815
Genus HAUSTELLUM Schumacher, 1817

Haustellum SCHUMACHER, 1817, Essai Nouv. Syst. Vers Test., p. 213.

Type species: *Murex haustellum* Linn., 1758, by tautonomy.

HAUSTELLUM POLYNEMATICUS (Brown and Pilsbry) Plate 1, figs. 1, 2

Murex (Murex) polynematicus BROWN and PILSBRY, 1911, Acad. Nat. Sci. Phila., Proc., v. 63, p. 353, pl. 26, fig. 1; OLSSON, 1964, Neogene Moll. Northwest. Ecuador, p. 137, pl. 29, figs. 2, 2a.

Murex (Murex?) polynematicus Brown and Pilsbry. WOODRING, 1959, U. S. Geol. Surv., Prof. Paper 306-B, p. 215, pl. 36, figs. 2, 3; pl. 37, figs. 6-9.

Murex (Murex) gilli polynematicus Brown and Pilsbry. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 101, pl. 2, fig. 5.

Murex messorius Sowerby. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, pl. 3, fig. 8 only (*not* of Sowerby).

Chicoreus (Siratus) gilli polynematicus (Brown and Pilsbry). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 183.

Not *Murex (Murex) polynematicus* Brown and Pilsbry. JUNG, 1965, Bulls. Amer. Paleontology, v. 49, no. 223, p. 520, pl. 69, fig. 6 [= *H. gilli* (Maury)].

Murex (Haustellum) polynematicus Brown and Pilsbry. VOKES, 1988, Tulane Stud. Geol. Paleont., v. 21, no. 1, p. 17, pl. 1, fig. 6.

Holotype: ANSP 1719; height 54.5 mm, diameter 33.7 mm.

Type locality: Gatun Formation; Gatun Locks, Panama.

Occurrence: Angostura Formation and Esmeraldas Beds, Ecuador. Gatun Formation, Panama; unnamed formation, Narĩno, Colombia; Pliocene.

Figured specimens: Fig. 1, USNM 445397; height 41.5 mm, diameter 27.4 mm; locality TU 1507. Fig. 2, USNM 445398; height 43.0 mm, diameter 25.5 mm; locality TU 1433.

Discussion: The generic placement of the species originally named *Murex polynematicus* and its close relative, originally named *Fusus gilli* Maury, 1910, has long been a problem to the writer. In a recent work (Ponder and Vokes, 1988) on the genus *Murex* s.s. in the Indo-Pacific, it was determined that the muricine species in the New World, which have been customarily assigned to *Murex* s.s., are better placed in the genus *Haustellum*. This causes problems for a few of the more spinose forms, but it is obvious that *Haustellum* is the correct genus for both *H. polynematicus* and its ancestor *H. gilli*. There should be no more changes for these two species, at least.

Haustellum polynematicus has been discussed in detail in a previous study on the Esmeraldas Beds (Vokes, 1988, p. 17) and little can be added at this point. The species, so far as we know, has no living descendants, although it was the most abundant and widespread muricid in the shallow-water of the Pliocene Panamic Province. Curiously, it never extended its range into the more northern Dominican Republic, where *H. messorius* (Sowerby, 1841) occupies the same ecologic niche, nor is it found in the Río Banano Formation of Costa Rica, which is only about 300 km from the contemporary occurrence in the Gatun Formation in Panama. In the Río Banano, *H. messorius* is also the *Haustellum* species that occurs. Obviously, *H. messorius* was a better competitor, as is borne out by the fact that *H. messorius* is still living today throughout the Caribbean and no trace of *H. polynematicus* is to be seen.

Subfamily THAIDINAE Jousseaume, 1888
Genus CERATOSTOMA Herrmannsen, 1846

Cerostoma CONRAD, 1837, Acad. Nat. Sci. Phila., Jour., v. 7, p. 263.

Type species: *Murex (Cerostoma) nuttalli* Conrad, 1837, by monotypy.

Ceratostoma HERRMANNSEN, 1846, Indicis Generum Malakoz., v. 1, p. 206. New name for *Cerostoma* Conrad, 1837, *non* Latreille, 1802.

Subgenus MICRORHYTIS Emerson, 1959

Microrhytis EMERSON, 1959, Amer. Mus. Novitates, no. 1974, p. 6.

Type species: *Pterorytis (Microrhytis) pecki* Emerson, 1959, by original designation.

Discussion: In a study of the genera of the Muricidae (Vokes, 1964, p. 23) I placed the subgenus *Microrhytis* in synonymy with the genus *Ceratostoma,* as both taxa are characterized by trivaricate shells that have a denticulate aperture and a strong labral tooth. However, the early whorls of *Ceratostoma* s.s. bear no varices but are simply cancellate until approximately the fifth teleoconch whorl, at which point three varices develop. In contrast, in *Microrhytis* (as in the genus *Pterorytis* Conrad, 1863, to which it is also closely related) on the early teleoconch whorls there are numerous small lamellar varices, which on approximately the fifth teleoconch whorl reduce their number to three.

The question arises as to whether *Microrhytis* is more closely allied with *Ceratostoma* or with *Pterorytis*. To me, the large open aperture with strong denticulations on the inside of the outer lip indicates a closer relationship with *Ceratostoma,* in contrast to the more circular, non-denticulate aperture of *Pterorytis*. In *Pterorytis* there are no intervarical nodes (even in specimens with only four varices) and the labral tooth is much larger than that seen in *Ceratostoma*. In addition, species of *Pterorytis* retain the more numerous varices (the least number in any species is four) and these varices are more wing-like and expanded than in *Microrhytis*. But, the case could be made for either placement with equal validity. The only species heretofore known of *Microrhytis* is the type, described from an unnamed formation in southern Mexico, in beds that have been dated by Akers (1972, p. 11) as late Middle Miocene (N 13-14) (TU 635, "Encanto Formation" of Akers). Until we have more material, placement of this taxon remains questionable.

CERATOSTOMA (MICRORHYTIS) ECUADORIUM Vokes, n. sp.
Plate 1, figs. 3, 4

Description: Shell of average size, probably six teleoconch whorls in adult; protoconch unknown. Spiral ornamentation on early teleoconch whorls of two strong cords, which persist up to the body whorl, where they form one weaker cord at the shoulder and another somewhat stronger cord just anterior to it. These supplemented by a third cord near base of the body whorl and numerous weaker threads between, and anterior to, the three major cords. Axial ornamentation on earliest whorls of approximately 12 small lamellar varices, crenulated by spiral cords; gradually reducing in number until on approximately the fifth teleoconch whorl becoming three varices with one strong intervarical node between each pair. Varices fimbriated on adapertural face, slightly recurved abaperturally, with a weak fold at shoulder. In addition to varices, the shell surface shagreened by numerous axial growth lines. At juncture of body whorl and siphonal canal a sharp adaperturally directed labral tooth, causing the varix to be enfolded behind it. Aperture large, ovate; columellar lip smooth, adnate posteriorly, free-standing anteriorly. Inner side of outer lip with approximately seven strong elongate denticles. Siphonal canal moderately long, wide, sealed over by an extension of shell material from columellar side; distal end slightly recurved. Paratype still showing color pattern of white spiral stripes overlying the major spiral cords on a solid brown background.

Holotype: USNM 445399; height 23.2 mm, diameter 15.5 mm (Plate 1, fig. 3).

Paratype: USNM 445400; height 26.8 mm, diameter 16.9 mm (Plate 1, fig. 4).

Type locality: TU 1507, Angostura Formation; Punta Verde, large point just east of Río Verde, or about 30 km east of Río Esmeraldas, Province of Esmeraldas, Ecuador.

Occurrence: Angostura Formation, Ecuador.

Discussion: There are just two specimens of this new species, one that is complete but immature, and a second that is mature but lacks the apertural side. Nevertheless, the form is so distinctive there is no question of its relationship with the Middle Miocene *Ceratostoma (Microrhytis) pecki* (Emerson), type of the subgenus. The Mexican species, described from the Gulf Coastal Plain side of the Is-

thmus of Tehuantepec, differs from the Ecuadorian one in lacking the relatively strong spiral cords and the shoulder fold in the varices, but otherwise the two are remarkably similar. These two species are the only known representatives of the subgenus *Microrhytis*.

The type locality of *C. (M.) pecki* (University of California, Museum of Paleontology A-8125) is the same as our locality TU 636, and is only 0.1 mile (0.16 km) from our locality TU 635 (= UCMP A-2184, locality of three paratypes), which, as noted above, has been dated as Middle Miocene. The fauna at these two localities indicates extremely shallow water with numerous specimens of a *Strombus* sp. cf. *S. proximus* Sowerby, 1850, described from the shallow-water Cercado Formation of the Dominican Republic. There is a large amount of fine gravel, and the assemblage, in general, looks as though it was almost intertidal. However, there is a good planktic foraminiferal fauna, which would not be found intertidally, and it is assumed that the mega-fossils were transported into the deep-water environment by a gravity-flow.

EUPLEURA OLSSONI Vokes, n. sp.
Plate 1, figs. 6, 7

Eupleura thompsoni Woodring subspecies. OLSSON, 1964, Neogene Moll. Northwest. Ecuador, p. 139, pl. 29, fig. 9.

Description: Shell small, seven teleoconch whorls; protoconch unknown. Spiral ornamentation on earliest teleoconch whorls of two sharp cords set very near anterior suture, leaving a wide, smooth, sloping shoulder ramp. On about sixth teleoconch whorl a weaker cord intercalated onto shoulder ramp. On body whorl about 12 cords, one at shoulder, one weaker on the shoulder ramp, and approximately 10 weaker ones anterior to shoulder, becoming progressively less strong anteriorly, very faint on siphonal canal; between each pair of major cords three to five extremely faint threads. Axial ornamentation on earliest teleoconch whorls of about 12 small lamellae, gradually reducing in number until on approximately the fifth teleoconch whorl only eight in number, with every fourth one becoming an expanded varix; three nodes remaining between each pair of varices. Varices aligned on opposite sides of the shell, with the varices of each successive whorl slightly in advance of varices on previous whorl, leaving a visible offset with varices not fused together. Intervarical nodes persisting as rounded knobs, over which the spiral ornamentation is diminished so that the knobs appear relatively smooth. Varices extended as a series of webbed scallops between points formed by extensions of the spiral cords, that at the shoulder the longest and adapically directed; on varical faces spiral cords expressed as grooves into which the shell laminae are enfolded. Aperture elongate-oval; inner lip appressed to columellar wall, with a few faint rugae reflecting underlying spiral cords. Margin of outer lip folded into the grooves of the varical face, especially at the shoulder; six strong denticles developed on inner side of outer lip, positioned between the grooves. Siphonal canal moderately long, straight, almost closed but open by a narrow slit.

Holotype: USNM 445402; height 26.3 mm, diameter 17.2 mm (Plate 1, fig. 6).

PLATE 1

Figures

1, 2. *Haustellum polynematicus* (Brown and Pilsbry) (X 1 1/2)
  1. USNM 445397; height 41.5 mm, diameter 27.4 mm.
     Locality: TU 1507, Angostura Formation, Punta Verde, Ecuador.
  2. USNM 445398; height 43.0 mm, diameter 25.5 mm.
     Locality: TU 1433, Gatun Formation, Prov. of Colón, Panama.

3, 4. *Ceratostoma (Microrhytis) ecuadorium* Vokes, n. sp. (X 2)
  3. USNM 445399 (holotype); height 23.2 mm, diameter 15.5 mm.
  4. USNM 445400 (paratype); height 26.8 mm, diameter 16.9 mm.
     Locality of both: TU 1507, Angostura Formation, Punta Verde, Ecuador.

5. *Typhis (Talityphis) alatus* Sowerby (X 2)
   USNM 445401; height 23.3 mm, diameter 14.8 mm.
   Locality: TU 1507, Angostura Formation, Punta Verde, Ecuador.

6, 7. *Eupleura olssoni* Vokes, n. sp. (X 2)
  6. USNM 445402 (holotype); height 26.3 mm, diameter 17.2 mm.
  7. USNM 445403 (paratype A); height (incomplete) 20.4 mm, diameter 18.0 mm.
     Locality of both: TU 1507, Angostura Formation, Punta Verde, Ecuador.

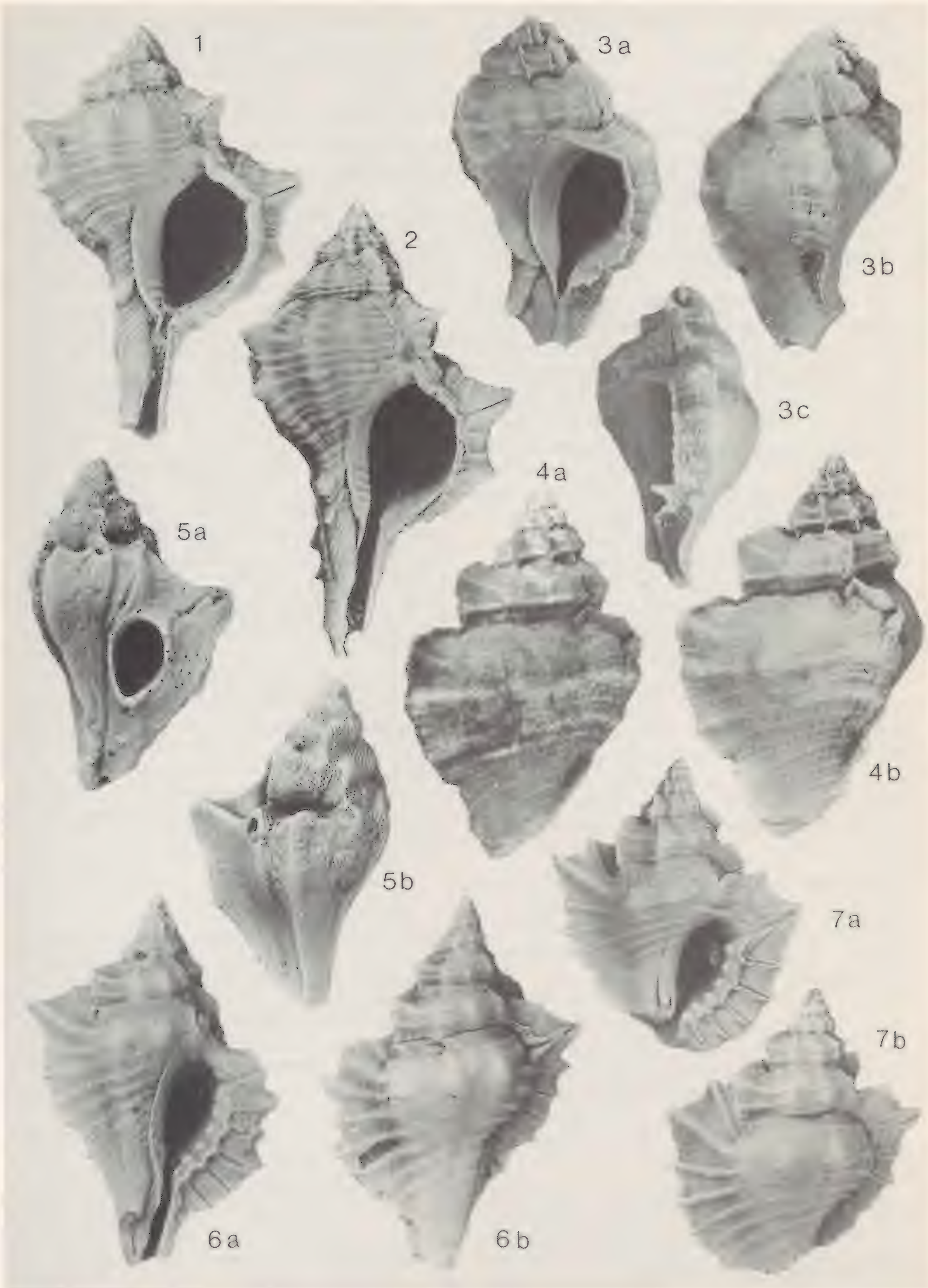


PLATE 1

Paratype A: USNM 445403; height (incomplete) 20.4 mm, diameter 18.0 mm; locality same as holotype (Plate 1, fig. 7).

Paratype B: USNM 643957; height 27.6 mm, diameter 18.2 mm; locality, Telembi, Río Cayapas, Ecuador (figured by Olsson, 1964, pl. 29, fig. 9).

Type locality: TU 1507, Angostura Formation; Punta Verde, large point just east of Río Verde, or about 30 km east of Río Esmeraldas, Province of Esmeraldas, Ecuador.

Occurrence: Angostura Formation, Ecuador.

Discussion: This is the species that Olsson (1964, p. 239) identified as "*Eupleura thompsoni* Woodring subspecies" but the two are no more than generically related. This new species is much more closely related to a second species of *Eupleura* that also occurs in the Gatun Formation, along with *E. thompsoni*, and it is possible that Olsson had specimens of this undescribed form included with *E. thompsoni*. In any case, the resemblance between the Gatun species, described elsewhere in this volume, and *E. olssoni*, n. sp., is very close. The two may be distinguished by the more scabrous appearance of the Gatun species, which has stronger secondary threads between the major cords and many axial growth lines that cause the surface of the shell to be laciniated. The Gatun species also has one more major spiral cord on the body whorl and the shoulder spines appear to be slightly more "upturned," *i. e.*, more adapically directed.

The shell of the new species here described is smoother than the Gatun form, and is more like the shell of "typical" *Eupleura*. It is an exciting example of evolutionary gradualism to see the changes from this species to the somewhat more ornamented Gatun form, to the extremely scabrous and nodulose *E. nitida* (Broderip, 1833), the representative of the line still living on the coast of Ecuador. The reader is referred to the accompanying paper (Vokes, 1989) for further discussion on this evolutionary sequence.

Eupleura olssoni bears a superficial similarity to the living Panamic species *E. muriciformis* (Broderip, 1833), which was reported from the Jama and Canoa formations of Ecuador by Pilsbry and Olsson (1941, p. 37*), but the Recent species has a much smoother surface texture; the spiral ornamentation appears almost as though the cords are under the surface of the shell, which is draped over them. These indistinct cords are the only spiral ornament; there are no secondary threads between them. There are also no spiral cords developed on the early whorls of *E. muriciformis*, nor is the cord on the shoulder, which gives rise to a varical spine between the suture and the shoulder spine, present. The shoulder spines of *E. olssoni* are not as long and are more adapically directed, having more the appearance of *E. triquetra* (Reeve, 1844), another living Panamic species that is sometimes confused with *E. muriciformis*.

This new species is undoubtedly a descendant of the Early Miocene *E. kugleri* Jung, 1965, described from the Cantaure Formation of the Paraguaná Peninsula, Venezuela. The most noticable difference between the two forms is the fact that, as Jung noted, on the body whorl of *E. kugleri* "the shoulder disappears" (Jung, 1965, p. 524). In *E. olssoni* the shoulder is marked on all of the whorls from the earliest up to and including the body whorl by a strong cord that gives rise to an extended shoulder spine. The shoulder ramp of *E. kugleri* is very flattened and the major spiral cord, and resulting spine, is that one at the periphery, so that the overall shape of the shell is more oval.

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*The material (Academy of Natural Sciences, Philadelphia, no. 15210) upon which this identification is made is truly a mixed bag. There are four specimens: two from the Jama Formation at Puerto Jama, of which one is *E. muriciformis* and the other, although poorly preserved, is probably *E. pectinata* (Hinds, 1844); the other two are from the Canoa Formation at Punta Blanca and include one example of *E. muriciformis* and one specimen of *Pteropurpura centrifuga* (Hinds, 1844)! Today the latter species does not extend farther south than Panama (Keen, 1971, p. 534) and the more southern equivalent is *P. deroyana* Berry, 1968, endemic to the Galapagos Islands. This occurrence provides the "missing link" between the two present day forms.

Subfamily TYPHINAE Cossmann, 1903
Genus TYPHIS Montfort, 1810

Typhis MONTFORT, 1810, Conchyl. Syst., v. 2, p. 614-615.

Type species: *Typhis tubifer* (Bruguière, 1792), by original desig.

Subgenus TALITYPHIS Jousseaume, 1882

Talityphis JOUSSEAUME, 1882, Rev. Mag. Zool., (Ser. 2) v 7, p. 338.

Type species: *Typhis expansus* Sowerby, 1874, by original desig.

TYPHIS (TALITYPHIS) ALATUS Sowerby
Plate 1, fig. 5

Typhis alatus G. B. SOWERBY, 1850, Geol. Soc. London, Quart. Jour. , v. 6, p. 48, pl. 10, fig. 4.

Typhis (Talityphis) alatus Sowerby. OLSSON, 1964, Neogene Moll. Northwest. Ecuador, p. 141; GERTMAN, 1969, Tulane Stud. Geol. Paleont., v. 7, no. 4, p. 159, text-fig. 3 (holotype); VOKES, 1983, Tulane Stud. Geol. Paleont., v. 17, no. 4, p. 124, pl. 1, figs. 1-3; VOKES, 1988, Tulane Stud. Geol. Paleont., v. 21, no. 1, p. 46, pl. 6, figs. 3, 4; VOKES, 1989, Bulls. Amer. Paleontology, v. 97, no. 332, p. 76, pl. 10, figs. 2-5, text-fig. 20 (holotype).

Holotype: British Museum (Natural History) GG. 20084; height 29.5 mm, diameter 18.0 mm.

Type locality: Gurabo Formation; Río Yaque, Dominican Republic (designated by Gertman, 1969, p. 160).

Occurrence: Esmeraldas Beds, Angostura and "Picaderos" [= Onzole] formations, Ecuador. Unnamed Middle Miocene formation, Dominican Republic. Gatun Formation, Panama; Gurabo Formation, Dominican Republic; Pliocene.

Figured specimen: USNM 445401; height 23.3 mm, diameter 14.8 mm; locality TU 1507.

Discussion: As has been noted previously in the Esmeraldas study, one specimen of *Typhis alatus* has been taken from each of the three units in the Ecuadorian Neogene – the Angostura, the Onzole (as Picaderos by Olsson, 1964, p. 141), and the Esmeraldas Beds (Vokes, 1988, p. 46). None are especially well-preserved, but in each case the identification is unmistakable, as each shows the characteristic elongated ridge anterior to the intervarical tube. As was also noted previously (Vokes, *ibid.*), the species is more common in deep-water deposits but there is a shallow-water example from the Gatun Formation (Vokes, 1983, pl. 1, fig. 2), so apparently the species did sometimes make its way into shallow water. The poor condition of the Angostura shell would indicate that it was probably a beach specimen.

With occurrences in Ecuador, Panama, and the Dominican Republic, in beds ranging in age from mid-Miocene to mid-Pliocene, *T. alatus* is one of the most widespread molluscan species in the amphi-American Tertiary. It is, however, never common. Even in the Gurabo Formation of the Dominican Republic, the "type area" of the species, we usually have no more than one or two specimens at any locality.

V. LOCALITY DATA

The following are Tulane University fossil locality numbers:

635. Unnamed formation, roadcut on Mexico Highway 185, 1.4 miles (2.3 km) south of bridge over Río Jaltepec, at Oaxaca-Veracruz state line, Mexico (= University of California, Museum of Paleontology locality A-8124; see Emerson, 1959, p. 6).
636. Unnamed formation, roadcut on Mexico Highway 185, 1.5 miles (2.4 km) south of bridge over Río Jaltepec, at Oaxaca-Veracruz state line, Mexico (= University of California, Museum of Paleontology locality A-8125; see Emerson, *ibid.**).
1433. Gatun Formation, north side of Boyd-Roosevelt Highway, clearing behind Urbanization San Martin, approximately 0.5 km east of junction of road to Refinería Panama, S.A., at Cativá, Prov. of Colón, Panama.
1507. Angostura Formation, large point just east of Río Verde, or approximately 30 km east of Río Esmeraldas, Prov. of Esmeraldas, Ecuador.

VI. LITERATURE CITED

AKERS, W. H., 1972, Planktonic foraminifera and biostratigraphy of some Neogene formations, northern Florida and Atlantic Coastal Plain: Tulane Stud. Geol. Paleont., v. 9, p. 1-139, pls. 1-60, 4 text-figs., 1 map.

EMERSON, W.K., 1959, The gastropod genus *Pterorytis:* Amer. Mus. Novitates, no. 1974, 8

*Although there is a slight discrepancy in the mileage/kilometrage, we have searched the area for a third locality and it does not exist. We are sure the two Tulane localities and the two Museum of Paleontology localities are the same.

p., 4 text-figs.
GERTMAN, R. L., 1969, Cenozoic Typhinae (Mollusca:Gastropoda) of the western Atlantic region: Tulane Stud. Geol. Paleont., v. 7, no. 4, p. 143-191, pls. 1-8, 3 text-figs.
JUNG, PETER, 1965, Miocene Mollusca from the Paraguana Peninsula, Venezuela: Bulls. Amer. Paleontology, v. 49, no. 223, p. 385-652, pls. 50-79, 2 tables, 3 text-figs.
KEEN, A. M., 1971, Sea shells of tropical west America. Marine mollusks from Baja California to Peru. Second Edition. Stanford University Press, Stanford, California. xiv + l064 p., 22 color plates, ca. 4000 figures, 6 maps.
OLSSON, A. A., 1964, Neogene mollusks from northwestern Ecuador. Paleontological Research Institution, Ithaca, New York. 256 p., 38 pls.
PILSBRY, H. A., and A. A. OLSSON, 1941, A Pliocene fauna from western Ecuador: Acad. Nat. Sci. Phila., Proc., v. 93, p. 1-79, pls. 1-19.
PONDER, W. F., and E. H. VOKES, 1988, A revision of the Indo-West Pacific fossil and Recent species of *Murex* s.s. and *Haustellum* (Muricidae: Gastropoda: Mollusca): Rec. Australian Mus., Suppl. 8, 160 p., 89 text-figs., 57 tables.
VOKES, E. H., 1964, Supraspecific groups in the subfamilies Muricinae and Tritonaliinae (Gastropoda:Muricidae): Malacologia, v. 2, no. 1, p. 1-41, pls. 1-3.
VOKES, E. H., 1983, Additions to the Typhinae (Gastropoda:Muricidae) of the Gatun Formation, Panama: Tulane Stud. Geol. Paleont., v. 17, no. 4, p. 123-130, pl. 1.
VOKES, E. H., 1988, Muricidae (Mollusca:Gastropoda) of the Esmeraldas Beds, northwestern Ecuador: Tulane Stud. Geol. Paleont., v. 21, no. 1, p. 1-50, pls. 1-6, 15 text-figs., 1 table.
VOKES, E. H., 1989, A new species of *Eupleura* (Gastropoda:Muricidae) from the Gatun Formation, Panama: Tulane Stud. Geol. Paleont., v. 22, no. 4, p. 118-122, pl. 1.
WHITTAKER, J. E., 1988, Benthic Cenozoic Foraminifera from Ecuador. British Museum (Natural History), London. xii + 194 p., 25 pls., 11 text-figs.

A NEW SPECIES OF *EUPLEURA* (GASTROPODA:MURICIDAE) FROM THE GATUN FORMATION, PANAMA

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In the process of determining the identity of the species cited by Olsson (1964, p. 139) as "*Eupleura thompsoni* Woodring subspecies," from the Angostura Formation of northwestern Ecuador, it became obvious that there are two species of *Eupleura* in the Gatun beds of Panama. One of these is the species named *Eupleura thompsoni* Woodring, 1959, and compared by him to the living *E. muriciformis* (Broderip, 1833). However, the similarity is much greater to the more spinose and long-canaled *E. pectinata* (Hinds 1844), which is found on the west coast of tropical America, from Mexico to Panama.

The second is a smaller form that is more closely related to another species living on the west coast of tropical America, *Eupleura nitida* (Broderip, 1833), characterized by nodulose intervarical areas and a scabrous surface texture. From the appearance of the new Gatun species, it is almost certainly ancestral to the rather atypical *E. nitida*.

In the Gatun Formation, *E. thompsoni* is by far the more common and widespread form. In the Tulane Collections we have over 500 specimens from seven localities. The new species is much rarer – it has only been taken at two localities, with just 50 specimens. The majority of these (47) are from one locality, TU 958, which must represent a different environment from most of the Gatun localities, as it was here that we also collected a large number of *Poirieria (Panamurex) gatunensis* (Brown and Pilsbry, 1911) (see Vokes, 1970, p. 42).

The genus *Eupleura* is a small group with but six Recent species (all well-figured by Radwin and D'Attilio, 1976, pl. 19, figs. 1-7), all found in the Western Hemisphere. Two of these are living today in the western Atlantic: *E. caudata* (Say, 1822), type of the genus, and *E. sulciden-*

tata Dall, 1890. Four are living in the eastern Pacific: *E. muriciformis* (Broderip, 1833), *E. triquetra* (Reeve, 1844), *E. pectinata* (Hinds, 1844) and *E. nitida* (Broderip, 1833). The relationship between the Atlantic and Pacific forms is interesting. The Pacific species *E. muriciformis* and *E. triquetra* are very closely related to the Atlantic *E. sulcidentata* and *E. caudata,* respectively. The other two Pacific species are most closely related to the two Gatun species treated herein. The Gatun is an Atlantic fauna but there are no living Atlantic descendants of either of these Gatun fossil species.

Class GASTROPODA
Order NEOGASTROPODA
Superfamily MURICACEA
Family MURICIDAE Rafinesque, 1815
Subfamily THAIDINAE Jousseaume, 1888
Genus *EUPLEURA* Adams and Adams, 1853

Eupleura H. ADAMS and A. ADAMS, 1853, Gen. Recent Mollusca, v. 1, p. 107.

Type species: *Ranella caudata* Say, 1822, by subsequent desig., F. C. Baker, 1895.

EUPLEURA THOMPSONI Woodring
Plate 1, figs. 6-8

Eupleura thompsoni WOODRING, 1959, U. S. Geol. Surv., Prof. Paper 306-B, p. 219, pl. 36, figs. 6-9.

Holotype: USNM 562587; height 45.7 mm, diameter 29.5 mm.

Type locality: Woodring locality 136A, Gatun Formation; north side Transisthmian (Boyd-Roosevelt) Highway, knoll about 30 m north of highway, 1.2 km northwest of Sabanita, Prov. of Colón, Panama.

Figured specimens: Fig. 6, USNM 445394; height 27.6 mm, diameter 16.9 mm. Fig. 7, USNM 445395; height 34.6 mm, diameter 21.0 mm. Fig. 8, USNM 445396; height 19.3 mm, diameter 12.2 mm. Locality of all, TU 958.

Occurrence: Gatun Formation, Panama. TU localities 958 (227 specimens), 961, 962, 757, 1411, 1432, 1433.

Discussion: When originally described, *E. thompsoni* was indicated by Woodring (1959, p. 219) as being the first western Atlantic species of *Eupleura* described south of Florida. Since that time, Jung has described two additional Caribbean fossil species: *E. kugleri* (1965, p. 524, pl. 70, figs. 3-6), from the Early Miocene Cantaure Formation, Venezuela; and *E. lehneri* (1969, p. 491, pl. 50, figs. 1-4), from the Late Miocene Melajo Clay, Trinidad. But, as Woodring noted, there are still no living species of the genus in the warmer waters of the Caribbean Sea.

However, the relationship of this Gatun species is not with the Caribbean fauna, as one might anticipate, but with the eastern Pacific fauna, *E. thompsoni* having a marked resemblance to the living *E. pectinata* (Hinds, 1844). The differences between the two forms include a much higher spire in *E. pectinata,* which also has a body whorl that is somewhat better deliniated from the longer siphonal canal. In *E. pectinata* the varices are more excavated on the abapertural side, the varical spines are longer, and the spine at the shoulder is more adapically directed. Moreover, the early whorls of the two species are so completely different that the resemblance between the two may be due only to convergence.

EUPLEURA PRENITIDA Vokes, n. sp.
Plate 1, figs. 1-4

Description: Shell small, seven teleoconch whorls in adult; protoconch unknown. Spiral ornamentation on earliest teleoconch whorls of two cords, a third partially covered by suture. Gradually secondary threads intercalated, until body whorl has approximately ten major cords, best seen on abapertural sides of varices, with between each pair, three to five secondary threads; another six faint threads on siphonal canal. Axial ornamentation on earliest teleoconch whorls of approximately 12 lamellae, diminishing in number and becoming more like axial ridges until about fifth teleoconch whorl two develop into varices, two per whorl, with three strong intervarical nodes between each pair. Varices not well-aligned on opposite sides of the shell, a marked offset between varices on succeeding whorls of as much as 30 degrees. Varices scalloped by extensions of the spiral cords, forming short spines, that at the shoulder directed adapically. Apertural face of the varices consisting of multiple laminae enfolded into grooves formed by the spiral cords, giving a lacinated appearance to the varical face. Shell surface between the varices also marked by numerous axial growth lines that cause shell material to be drawn out adaperturally where the spiral threads are crossed, giving the entire shell surface a lacinated appearance. Aperture elongate-oval; inner lip adnate, with numerous faint rugae reflecting the underlying spiral cords;

margin of outer lip reflected abaperturally, crenulated by grooves of spiral cords; inner side with six strong denticles located between the spiral cords. Siphonal canal moderately long, straight, almost closed over but open by a narrow slit.

Holotype: USNM 445390; height 31.1 mm, diameter 17.7 mm (Plate 1, fig. 1).

Paratype A: USNM 445391; height 27.0 mm, diameter 17.2 mm; locality same as holotype (Plate 1, fig. 2).

Paratype B: USNM 445392; height (incomplete) 23.5 mm, diameter 14.6 mm, locality same as holotype (Plate 1, fig. 3).

Paratype C: USNM 445393; height 15.3 mm, diameter 9.5 mm, locality same as holotype (Plate 1, fig. 4).

Type locality: TU 958, Gatun Formation, hillslope on east side of road from Boyd-Roosevelt Highway to Refinería Panama, S. A., about 0.5 km north of junction, just east of Cativá, Prov. of Colón, Panama.

Occurrence: Gatun Formation, Panama. TU localities 958 (47 specimens), 1431 (3 specimens).

Discussion: This new species occurs together with the more common *E. thompsoni* at only two localities and at only one of these, the type locality, does it occur in any numbers. There is no possibility of confusing it with *E. thompsoni,* as the two have only a generic resemblance. The species to which it is most closely related is a new species, described elsewhere in this volume (Vokes, 1989), from the Late Miocene Angostura Formation of Ecuador. From the slightly older species the Panama shell differs in its more scabrous nature, which is a result of the combination of stronger secondary spiral ornamentation crossed by axial growth lines. In addition, the shoulder spines of the Panama species are more upturned and the varical offset is greater. Nevertheless the two species are extremely close and are more closely related to each other than to any other known species.

There is another species, *E. lehneri* Jung, described from the Late Miocene Melajo Clay of Trinidad (Jung, 1969, p. 491, pl. 50, figs. 1-4) that has a superficial resemblance to this new species. The Trinidadian species has longer spines than *E. prenitida,* with more expanded varices and a longer canal. The surface of *E. lehneri* is smoother than that of *E. prenitida,* except for the major spiral cords. In many ways, *E. lehneri* has a stronger resemblance to the living *E. pectinata* than to *E. prenitida.* The spines extending beyond the varical webbing, the extreme adapical angle of the shoulder spine, and the smooth surface texture all suggest that, perhaps, *E. lehneri* gave rise to *E. pectinata,* and *E. thompsoni* is not part of the direct lineage.

It is presumed that the new Panama species gave rise to the Recent *E. nitida* (Broderip, 1833), which today lives in the eastern Pacific from Mexico to Ecuador. The living species has the same sort of lacinated surface texture that is seen in *E. prenitida,* but differs in having small nodules developed where the spiral cords cross the intervarical nodes. The varices are also

PLATE 1

Figures

1-4. *Eupleura prenitida* Vokes, n. sp.
   1. (X 2) USNM 445390 (holotype); height 31.1 mm, diameter 17.7 mm.
   2. (X 2) USNM 445391 (paratype A); height 27.0 mm, diameter 17.2 mm
   3. (X 2) USNM 445392 (paratype B); height (incomplete) 23.5 mm, diameter 14.6 mm.
   4. (X 3) USNM 445393 (paratype C); height 15.3 mm, diameter 9.5 mm.
   Locality of all: TU 958, Gatun Formation, Panama.

5. *Eupleura nitida* (Broderip, 1833)
   (X 2) USNM 860472; height 22.1 mm, diameter 15.5 mm.
   Locality: TU R-188, Venado Beach, Panama.

6-8. *Eupleura thompsoni* Woodring
   6. (X 2) USNM 445394; height 27.6 mm, diameter 16.9 mm.
   7. (X 2) USNM 445395; height 34.6 mm, diameter 21.0 mm.
   8. (X 3) USNM 445396; height 19.3 mm, diameter 12.2 mm.
   Locality of all: TU 958, Gatun Formation, Panama.

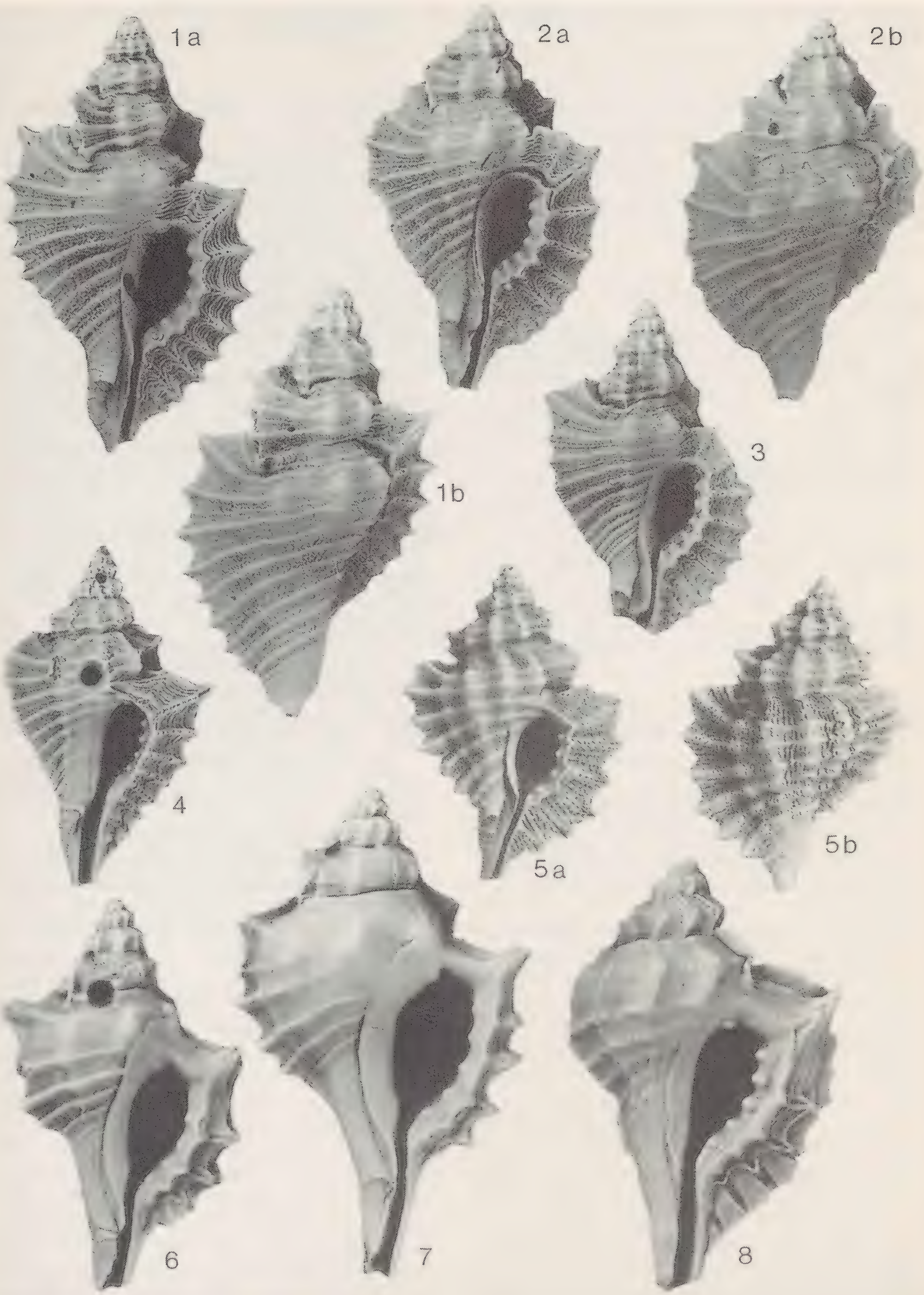

PLATE 1

more perfectly aligned on opposite sides of the shell.

Most species of *Euplera* have an almost totally smooth shell surface and it is an interesting evolutionary sequence to see the development from the relatively smooth Ecuadorian species, to the moderately scabrous *E. prenitida* to the Recent *E. nitida,* which is so scabrous as to appear frosted when the shell is unworn (see plate 1, fig. 5).

LOCALITY DATA

The following are Tulane University fossil locality numbers. All are from the Gatun Formation, Province of Colón, Panama.

757. Roadcut on south side of Boyd-Roosevelt Highway at junction of road to Refinería Panama, S. A., just east of Cativá.
958. Hillslope on east side of road from Boyd-Roosevelt Highway to Refinería Panama, S. A., about 0.5 km north of junction, just east of Cativá.
961. Roadcuts north and south side of Boyd-Roosevelt Highway, just east of Cativá (= Woodring locality 138).
962. Roadcut on road to Refinería Panama, S. A., about 0.5 km south of the gate; hillcut and fill for new (1968) power plant construction.
1431. Hilltop construction site, 0.5 km northwest of intersection of Boyd-Roosevelt Highway and road to Puerto Pilon, at Sabanita.
1432. North side of Boyd-Roosevelt Highway, clearing behind Residential Martin Luther King (formerly Palo Quemado), approximately 1.5 km east of junction of road to Refinería Panama, S. A., at Cativá.
1433. North side of Boyd-Roosevelt Highway, clearing behind Urbanization San Martin, approximately 0.5 km east of junction of road to Refineriá Panama, S. A., at Cativá.

The following is a Tulane University Recent locality number:

R-188. Venado Beach, Pacific Ocean, just west of Canal Zone-Panama boundary line, Canal Zone.

LITERATURE CITED

JUNG, PETER, 1965, Miocene Mollusca from the Paraguana Peninsula, Venezuela: Bulls. Amer. Paleontology, v. 49, no. 223, p. 385-652, pls. 50-79, 2 tables, 3 text-figs.

JUNG, PETER, 1969, Miocene and Pliocene mollusks from Trinidad: Bulls. Amer. Paleontology, v. 55, no. 247, p. 289-657, pls. 13-60, 4 text-figs.

OLSSON, A. A., 1964, Neogene mollusks from northwestern Ecuador. Paleontological Research Institution, Ithaca, New York. 256 p., 38 pls.

RADWIN, G. E., and A. D'ATTILIO, 1976, *Murex* shells of the world; an illustrated guide to the Muricidae. Stanford University Press, Stanford, California. 284 p., 32 pls., 192 text-figs.

VOKES, E. H., 1970, Cenozoic Muricidae of the western Atlantic region. Part V – *Pterynotus* and *Poirieria:* Tulane Stud. Geol. Paleont., v. 8, no. 1, p. 1-50, pls. 1-7, 1 text-fig.

VOKES, E. H., 1989, Muricidae (Mollusca:Gastropoda) of the Angostura Formation, northwestern Ecuador: Tulane Stud. Geol. Paleont., v. 22, no. 4, p. 107-118, 1 pl., 7 text-figs.

WOODRING, W. P., 1959, Geology and Paleontology of Canal Zone and adjoining parts of Panama: Description of Tertiary mollusks (Gastropods: Vermetidae to Thaididae): U. S. Geol. Surv., Prof. Paper 306-B, p. 147-239, pls. 24-38.

December 28, 1989

ON THE OCCURRENCE OF THE CARIBBEAN SPECIES *HAUSTELLUM CHRYSOSTOMA* (GASTROPODA: MURICIDAE) IN THE PLIOCENE OF WESTERN ECUADOR

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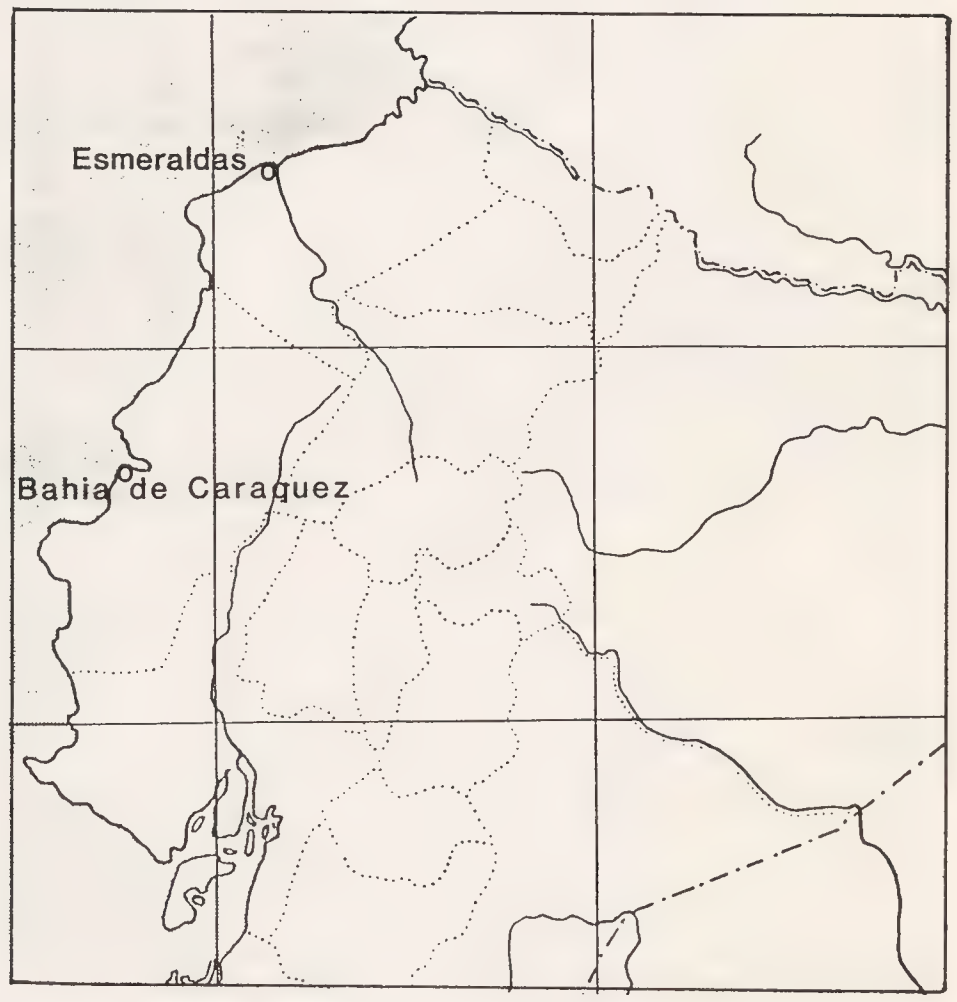
A reconnaissance trip along the coast of western Ecuador to the south of the city of Bahía de Caráquez, Manabi Province (text-fig. 1), proved to be unproductive from the perspective of fossil mollusks. The sea cliffs are very impressive (text-fig. 2), with magnificent exposures accessible at low tide by driving along the beach. Although Bristow (1976, p. 198) lists about two dozen species of mollusks from the "Borbón Formation," in the "coast section south of Bahía," we were unable to find his locality. There was a single thin lens exposed, which yielded a few poorly preserved shells and this may be his locality, now weathered and essentially gone. Or, he may have collected somewhere farther down the beach than we went. In any case, in spite of closely examining the cliffs for several kilometers to the south of Bahía, we saw only one fossiliferous lens.

This outcrop would not be worth mentioning except that among the few fossil mollusks we did collect were two examples of a muricid gastropod (pl. 1, fig. 2) that proves to be identical with the Recent Caribbean species, *Haustellum chrysostoma* (Sowerby, 1834), which lives today along the coast of Venezuela (pl. 1, fig. 1).

Although Bristow assigned the beds at Bahía to the Borbón Formation, more recently Whittaker (1988, p. 24) has erected the name Bahía Formation, based upon Olsson's (1942, p. 263, and correlation chart, p. 256) usage of the name for the beds exposed in the sea cliffs between Bahía and Punta Charapotó, beds Olsson considered to be Middle Miocene in age. Whittaker dates the beds on the basis of age of the underlying beds, there being no diagnostic foraminifers in the unit, as Early Pliocene (N 18/19) and correlates them with the Jama Formation to the north. They are also the same age as the Esmeraldas Beds of the Upper Onzole Formation in the northwestern part of Ecuador (see Vokes, 1988). From Whittaker's figure 5 (1988, p. 16) (see text-fig. 3) we assume our locality to be approximately equal to his locality number CRB 124.



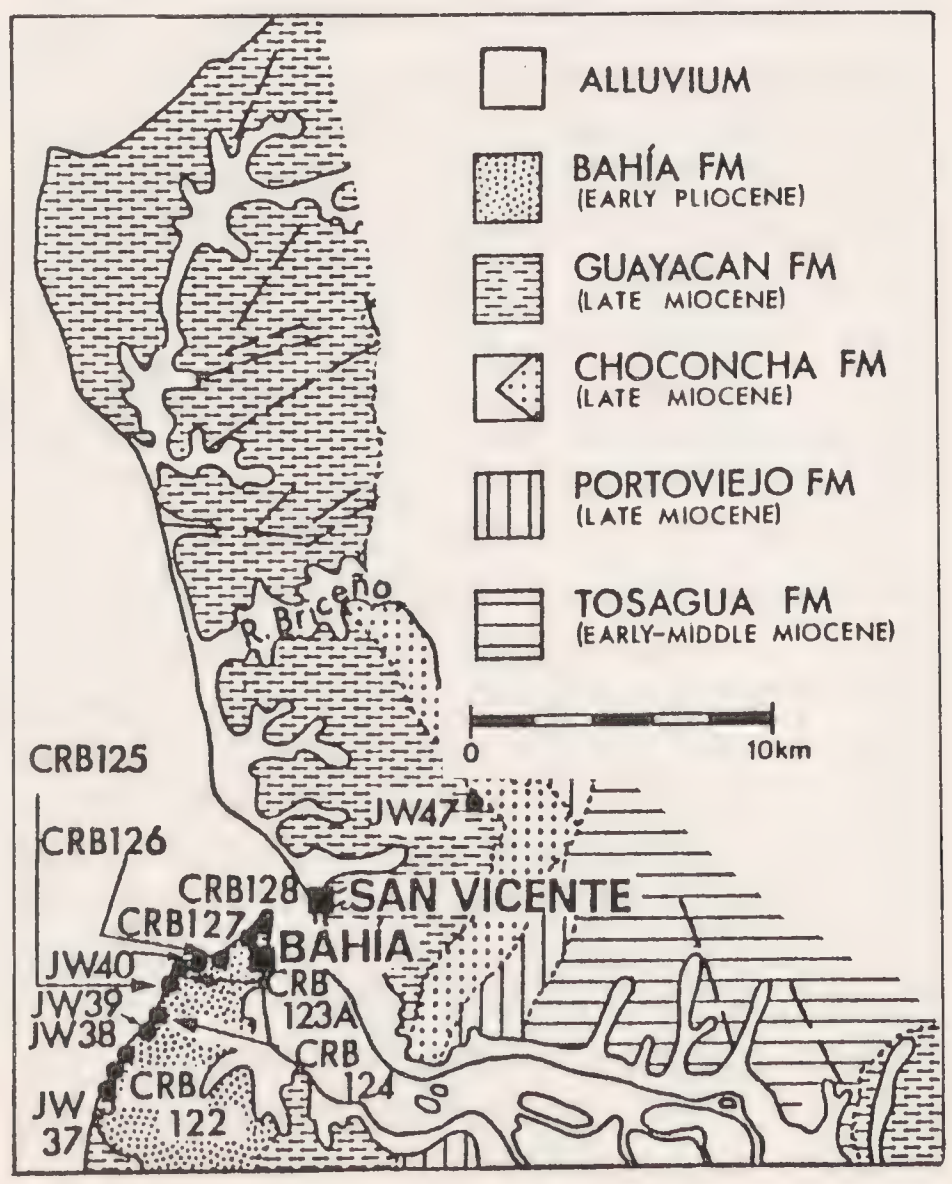
Text-figure 1. Map of western Ecuador, showing study area.

The species *Haustellum chrysostoma* has been reported from the basal beds of the Late Miocene Melajo Clay of Trinidad by Jung (1969, p. 489, pl. 49, figs. 8-10). He notes that the basal beds of the Melajo represent "a typical, tropical, near-shore fauna" (*ibid.*, p. 305) and this is corroborated by Recent specimens in my collection that are identical to Jung's figured specimens and were taken in 3 m depth, Paraguaná Peninsula, Venezuela. A typical specimen was also figured by Weisbord (1962, p. 282, pl. 25, figs. 17, 18) from the lower Mare Formation of Venezuela. These beds were considered to be Lower Pliocene by Weisbord but more recent work on the planctic foraminifera indicates an Early Pleistocene age (*Lexico Estratigrafico de Venezuela,* 1970, p. 400). The species is also abundant in the Cumaná Formation of north-central Venezuela (pl. 1, fig. 3). The age of these beds has been considered to be Pliocene by most authors but the *Lexico Estratografico de Venezuela* (1970, p. 187) moves the age up to Pleistocene on the grounds that the zone of *Globoratalia truncatulinoides* (N 21-23) has

Text-figure 2. Sea cliffs along the coast, south of Bahía de Caráquez, Manabi Province, Ecuador.

been reassigned to the Pleistocene.

Haustellum chrysostoma is closely related to *H. polynematicus* (Brown and Pilsbry, 1911), which, although described from the Gatun Formation of Panama, also occurs in the Esmeraldas Beds of northwestern Ecuador, and unnamed beds in Colombia (see Vokes, 1988, p. 17). But the species first occurs in the Angostura Formation of Ecuador (see Olsson, 1964, p. 137, pl. 29, figs. 2, 2a, and Vokes, this volume), beds that Whittaker (1988, p. 11) dates as probably Late Miocene. Thus, the two species are contemporaneous. It is assumed that *H. polynematicus* is derived from the Early Miocene species *H. gilli* (Maury, 1910), from the Chipola Formation



Text-figure 3. Geologic map of area in the vicinity of Bahía de Caráquez, taken from Whittaker, 1988, figure 5, showing his locality numbers.

PLATE 1

Figures

1–3. *Haustellum chrysostoma* (Sowerby) (X 1 1/2)

1. USNM 860471; height 74.6 mm, diameter 35.3 mm.
   Locality El Pico, Paraguaná Peninsula, Venezuela, 3 m depth.
2. USNM 445384; height (incomplete) 30.5 mm, diameter (incomplete) 32.2 mm.
   Locality: Sea cliffs approximately 5 km southwest of Bahía de Caráquez, Ecuador. Bahia Formation, Early Pliocene.
3. UCMP 38570; height 44 mm (incomplete), diameter 36.5 mm.
   Locality: Northern end Cumaná Hills, about 6 km east of the "Castillo," at Cumaná, Venezuela. Cumaná Formation, Early Pleistocene.

of northwestern Florida, and the correlative Cantaure Formation of Venezuela (see Vokes, 1988, p. 17, for further discussion of this later occurrence, originally cited by Jung, 1965, p. 520, pl. 69, fig. 6, as *Murex polynematicus)*. However, *H. chrysostoma* does not especially resemble *H. gilli*, and so the origins of the line are uncertain. Perhaps the two younger species represent parallel lines of development and *H. gilli* gave rise to both *H. polynematicus*, which did not survive the Pliocene, and to *H. chrysostoma*.

In the Recent Caribbean fauna *H. chrysostoma* occurs together with the superficially similar appearing *H. messorius* (Sowerby, 1841). It is my opinion that the two forms represent convergence, with *H. messorius* having been a Caribbean species since at least the Early Miocene. It first occurs in the Early Miocene Baitoa Formation of the Dominican Republic (Vokes, 1989, p. 26) and the Pirabas Formation of Brazil (as *Murex sutilis* White, 1887). It also occurs in a number of other Tertiary formations throughout the Caribbean, being the most abundant and widespread of the species of *Haustellum* in the western Atlantic.

In the Caribbean *H. messorius* has persisted without any great change since the Early Miocene. It is an extremely variable species and a number of names have been proposed for what I consider to be infraspecific variations. It occurs in shallow-water at localities ranging from the Greater Antilles to Venezuela. The range of *H. chrysostoma* is much more limited, occurring only along the coast of Venezuela, (including Trinidad and Tobago), as far west as the Goajira Peninsula, Colombia.* In the Dutch Antilles and as far north as approximately Guadeloupe, Lesser Antilles, *H. chrysostoma bellus* (Reeve, 1845) occurs.

There is a strong superficial resemblance between the species *H. chrysostoma* and *H. messorius*, and there is no simple way to differentiate the two. In general, *H. chrysostoma* is smoother, has a more appressed suture, one to two rows of intervarical nodes, a more inflated body whorl and, hence, a larger aperture, with a more expanded parietal shield that is at least partially yellow in color. There are no spines on the varices, only a short recurved spine at the base of the body whorl. In general, *H. messorius* is a smaller species, with more nodulose intervarical ornamentation, two to three rows of intervarical nodes, and a short spine at the shoulder (in some forms numerous short spines on the varices). But all of these characters may appear in either species. In the end, it is the overall aspect of the shell that indicates placement in one or the other species and all too often there are those enigmatic intermediate forms that defy placement. Nevertheless, I still believe that there are two valid species present – we just cannot always separate them.

LITERATURE CITED

BRISTOW, C.R., 1976, The Daule Group, Ecuador (Middle Miocene-Pliocene): Newsl. Stratigr., v. 5, nos. 2/3, p. 190-200, 2 text-figs.

GONZALEZ, A. R., and C. FLORES, 1972, Nota sobre los generos *Thais* Roeding, *Purpura* Brugiere *[sic]* y *Murex* Linnaeus (Neogastropoda: Muricidae) en las aguas costeras de Venezulea: Inst. Oceanogr., Univ. Oriente, Bol., v. 11, no. 2, p. 67-82, 11 text-figs.

JUNG, PETER, 1965, Miocene Mollusca from the Paraguana Peninsula, Venezuela: Bulls. Amer. Paleontology, v. 49, no. 223, p. 385-652, pls. 50-79, 2 tables, 3 text-figs.

JUNG, PETER, 1969, Miocene and Pliocene mollusks from Trinidad: Bulls. Amer.

*The Brazilian shell that has been called *Murex chrysostoma* by Rios (1985, p. 81, pl. 29, fig. 354) is a different species. Rios notes that *M. chrysostoma* may be "distinguished from *messorius* by the radular teeth." This erroneous statement is based upon the illustration given by Gonzalez and Flores (1972, fig. 9-c) of a thaidine radula (probably *Thais haemastoma)* as *"Murex chrysostomus."* There is no difference in the radulae of *H. messorius* and *H. chrysostoma*, both are typically muricine. These authors also show for the radula of *Murex donmoorei* (their fig. 9-b) another thaidine radula. As a guess, the illustrations have been mixed with their fig. 2, showing as rachidian teeth of *Thais deltoidea*, *T. rustica*, and *T. haemastoma floridana*, three illustrations of muricine radulae.

Paleontology, v. 55, no. 247, p. 289-657, pls. 13-60, 4 text-figs.
LEXICO ESTRATIGRAFICO DE VENEZUELA (Segunda Edición), 1970, Rep. de Venezuela, Min. Minas e Hidrocarb., Direccion de Geol., Bol. Geol., Publ. Espec. no. 4, 756 p., 2 maps, 1 correlation chart.
OLSSON, A. A., 1942, Tertiary deposits of northwestern South America and Panama: Eighth American Sci. Cong., Proc., v. 4, p. 231-287.
OLSSON, A. A., 1964, Neogene mollusks from northwestern Ecuador. Paleontological Research Institution, Ithaca, New York. 256 p., 38 pls.
RIOS, E. C., 1985, Seashells of Brazil. Fund. Univ. Rio Grande, Mus. Ocean., Rio Grande, RGS, Brazil. 329 p., 102 pls.
VOKES, E. H., 1988, Muricidae (Mollusca: Gastropoda) of the Esmeraldas Beds, northwestern Ecuador: Tulane Stud. Geol. Paleont., v. 21, no. 1, p. 1-50, pls. 1-6, 1 table, 15 text-figs.
VOKES, E. H., 1989, Neogene Paleontology in the northern Dominican Republic. 8. The family Muricidae (Mollusca: Gastropoda): Bulls. Amer. Paleontology, v. 97, no. 332, p. 5-94, pls. 1-12, 2l text-figs., 3 tables.
WEISBORD, N. E., 1962, Late Cenozoic gastropods from northern Venezuela: Bulls. Amer. Paleontology, v. 42, no. 193, p. 1-672, pls. 1-48.
WHITTAKER, J. E., 1988, Benthic Cenozoic Foraminifera from Ecuador. British Museum (Natural History), London. xii + 194 p., 25 pls., 11 text-figs.

December 28, 1989

NOTES ON THE FAUNA OF THE CHIPOLA FORMATION – XXXI ON THE OCCURRENCE OF THE GENUS *CORALLIOPHAGA* (MOLLUSCA:BIVALVIA)

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In 1898, Dall published figures of a shell from the "Ballast Point silex beds" that he named *Coralliophaga elegans* (pl. 25, figs. 2, 2a). In 1903 (p. 1499) he described the species as *C. elegantula,* noting that the specific name *elegans* had been used by Deshayes in 1824, and listing the occurrences as "Upper Oligocene of the Chipola marl, Chipola River, Florida, and of the silex beds at Ballast Point, Tampa Bay." Julia Gardner, however, did not mention this name in her monograph of the fauna of the Alum Bluff Group (1926-1950) and Mansfield in his "Mollusks of the Tampa and Suwannee Limestones of Florida," states (1937, p. 228): "Although Dall reports this species in the Chipola formation, I have not seen it from that locality." Insofar as I have been able to ascertain, this erroneous citation is the only mention of the genus *Coralliophaga* in the Chipola fauna.

Examination of the extensive Chipola collections at Tulane University has yielded a number of specimens referable to *Coralliophaga coralliophaga* (Gmelin) from seven localities, plus four specimens having a *Coralliophaga*-like hinge but lacking all radial ornamentation; these come from three localities, two of which have not yielded representatives of *C. coralliophaga.*

Family TRAPEZIIDAE Lamy, 1920
Genus CORALLIOPHAGA Blainville, 1824

Coralliophaga BLAINVILLE, 1824, Man. de Malac. et Conchyl., p. 560.

Type species: *Coralliophaga carditoidea* Blainville, 1824 (= *Chama coralliophaga* Gmelin, 1791), by monotypy. Recent: Red Sea, Indian Ocean, and western Pacific Ocean northward to Japan; Bermuda, North Carolina to Florida,

Texas, Antilles and Caribbean, from Costa Rica eastward to northern Brazil.

Description: "Coquille ovale, alongée, finement radiée du sommet à la base, cylindrique, équivalve, très-inéquilatérale; les sommets dorsaux très-anterieurs et peu marqués; charnière subsimilaire; deux petites dents cardinales, dont une est subbifide, au-devant d'une sorte de dent lamelleuse, sous un ligament extérieur assez foible; deux impressions musculaires, petites, arrondies, distantes, réunies par une impression palléale étroite, et assez excavée en arrière." (Blainville, 1824)

CORALLIOPHAGA CORALLIOPHAGA (Gmelin)
Figures 1-3

Chama coralliophaga GMELIN, 1791, Systema Naturae, ed. 13, p. 3305.
Cardita dactylus BRUGUIÈRE, 1792, Encycl. Méth., Hist. Nat. Vers, v. 1, p. 412.
Cypricardia coralliophaga LAMARCK, 1819, Hist. Nat. Anim. s. Vert., v. 6, pt. 1, p. 28.
Coralliophaga carditoidea BLAINVILLE, 1824, Man. de Malac. et Conchyl., p. 560, pl. 76, fig. 5.
Petricola carditoidea (Blainville). SOWERBY, 1839, Conch. Man., p. 119, pl. 28, fig. 92.
Cypricardia hornbeckiana D'ORBIGNY, 1842, Moluscos *in* de la Sagre, Hist. Fis. Pol. y Nat., Isla de Cuba, pt. 2, Hist. Nat., v. 5, atlas, pl. 26, figs. 33, 34; text, p. 312 [1846].

Description: Shell relatively thin, somewhat variable in shape, reflecting its habit of living in burrows of other animals, usually elongately ovate, somewhat modioliform with short, rounded, anterior end and broader, convex posterior one; umbones near anterior end, low, inconspicuous; valves ornamented with fine radial ribbing that is weak on anterior margin immediately posterior to umbones, and with concentric growth lines that tend to develop lamellate projecting ridges posteriorly and posteroventrally; anterior adductor scar relatively small, at anterior extremity, posterior adductor scar larger, somewhat elongate along dorsal margin; pallial sinus short, angular; hinge with two relatively elongate, narrow cardinal teeth and one posterior lateral tooth in each valve.

Figured specimens: Fig. 1, USNM 445385; length 27.7 mm, height 11.9 mm, diameter (right valve) 4.8 mm; locality TU 555, Chipola River. Fig. 2, USNM 445386; length 24.6 mm, height 9.6 mm, diameter (paired valves) 4.9 mm; locality TU 550, Chipola River. Fig. 3, USNM 445387; length 19.9 mm, height 11.5 mm, diameter (left valve) 4.7 mm; locality TU 1196, Farley Creek.

Other Chipola Formation occurrences: TU 555 - two right and one left valves; TU 821 - one right valve; TU 830 - one paired valve specimen, plus one right valve; TU 1048 - three paired valve specimens; TU 1049 - two right valves; TU 1196 - 3 paired valve specimens.

Discussion: As far as the writer has been able to ascertain, the present record of the occurrence of *Coralliophaga coralliophaga* in the fauna of the Early Miocene (Burdigalian) Chipola Formation represents the geologically oldest record of its presence in the faunas of the western Atlantic region. Maury (1917, p. 197) reported it from the Late Miocene Cercado Formation, at Caimito on the Rio Cana, Dominican Republic, and Dall (1903, p. 1498) from the uppermost Pliocene of the Caloosahatchee River, plus Pleistocene occurrences in the West Indies.

The great variation in shape of the shells of *C. coralliophaga* appears to be caused by the nature of the particular hole occupied by the animal which, as noted by Perry (1940, p. 69) "lives in burrows of other mollusks, sometimes several in one cavity, and occasionally with the original owner." Bales (1944, p. 48) reported that in the Florida area it usually occurs in *Lithophaga* burrows.

For an extensive listing of earlier papers relative to this species see Solem (1954, p. 77).

CORALLIOPHAGA DELIQUIRADIA, n. sp.
Figures 4, 5

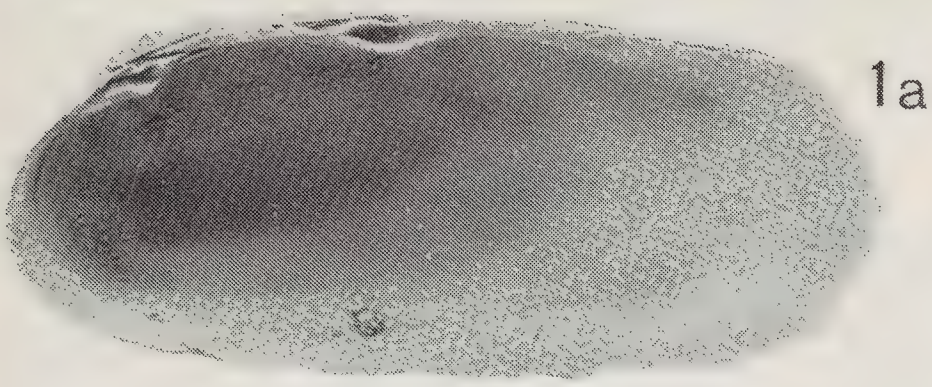
Description: Shell with a shape similar to that in the rather broad, less elongate variants of *C. coralliophaga,* ornamented by strong, exceedingly irregular concentric laminations very unlike those on the valves of the genotypic species, and with no radial ribbing; hinge and pallial sinus similar to those of *C. coralliophaga.*

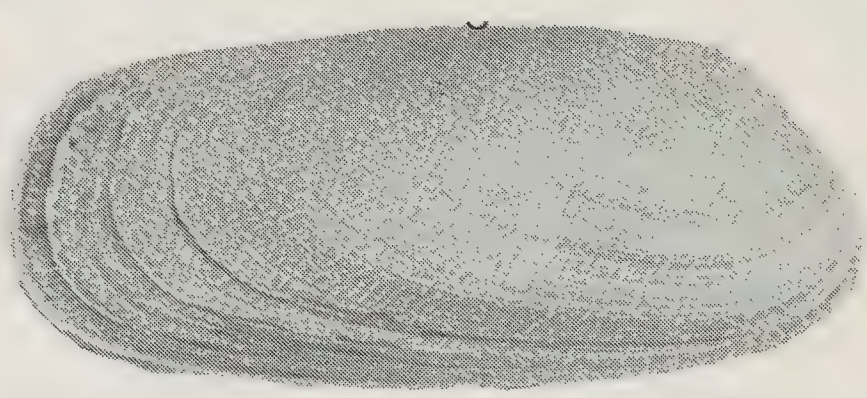
Holotype: USNM 445388; length 23.7 mm, height 13.1 mm, diameter (right valve) 5.7 mm (Figure 4).

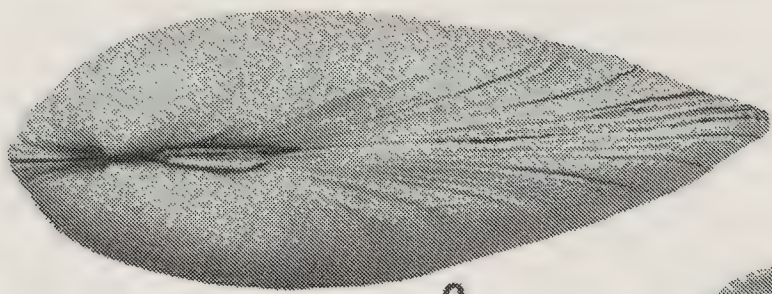
Paratype: USNM 445389; length (incomplete) 23.1 mm, height 13.3 mm, diameter (right valve) 5.6 mm; locality TU 1050, Chipola River (Figure 5).

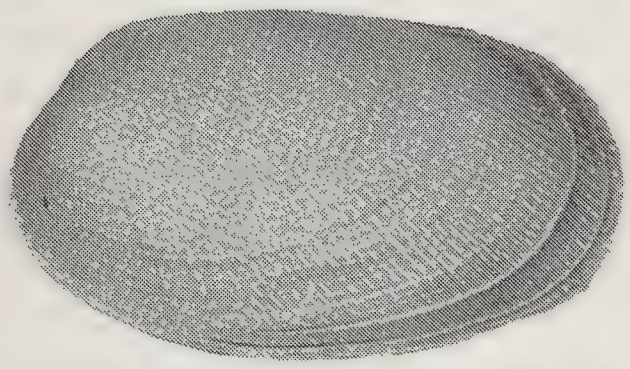
Type locality: TU 1196, Chipola Formation, Farley Creek, north bank about 0.8 mile east of bridge on Florida Highway 275 (NE 1/4 Sec. 21, T1N, R9W), Calhoun County, Florida.

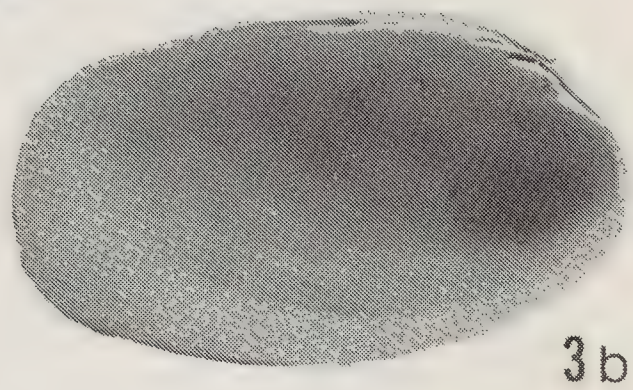
Discussion: There are in the Tulane Collections four valves of this species from three localities: TU 458, Chipola River; TU 1050, Chipola River; and TU 1196 (two valves), Farley Creek. These are here named as a new species rather than an ex-

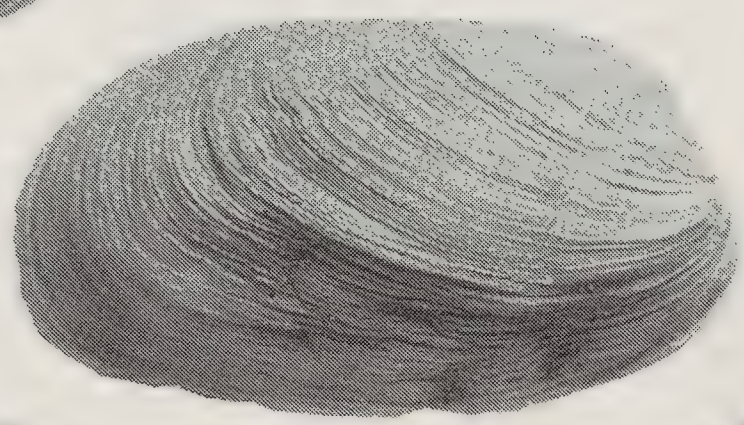


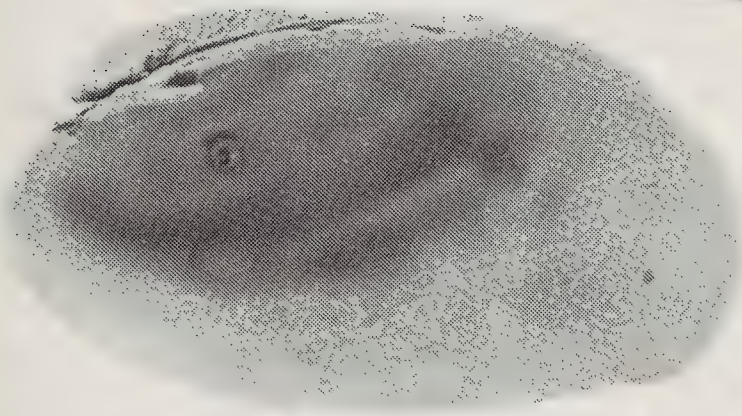


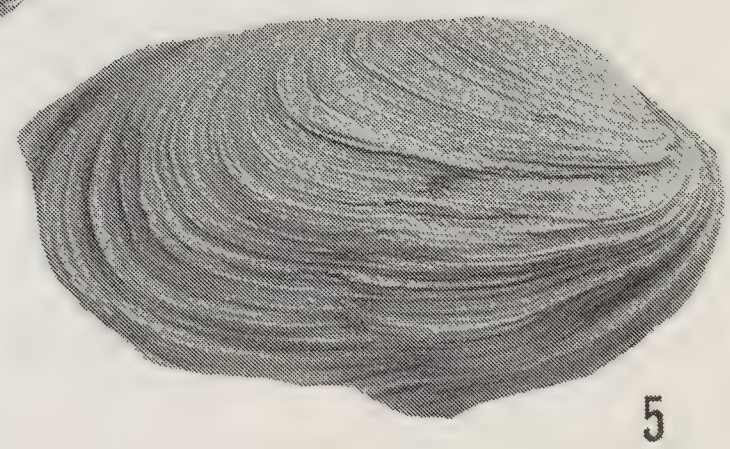












FIGURES

1-3. *Coralliophaga coralliophaga* (Gmelin) (X 2)
   1. USNM 445385; length 27.7 mm; height 11.9 mm, diameter (right valve) 4.8 mm.
      Locality: TU 555, Chipola Formation, Chipola River, Florida.
   2. USNM 445386; length 24.6 mm, height 9.6 mm, diameter (paired valves) 4.9 mm.
      Locality: TU 550, Chipola Formation, Chipola River, Florida.
   3. USNM 445387: length 19.9 mm, height 11.5 mm, diameter (left valve) 4.7 mm.
      Locality: TU 1196, Chipola Formation, Farley Creek, Florida.

4, 5. *Coralliophila deliquiradia* H. E. Vokes, n. sp. (X 2)
   4. USNM 445388 (holotype); length 23.7 mm, height 13.1 mm, diameter (right valve) 5.7 mm.
      Locality: TU 1196, Chipola Formation, Farley Creek, Florida.
   5. USNM 445389 (paratype): length (incomplete) 23.1 mm, height 13.3 mm, diameter (right valve) 5.6 mm.
      Locality: TU 1050, Chipola Formation, Chipola River, Florida.

treme variant of *C. coralliophaga*. The specific name is derived from the Latin *deliquus*, = "lacking," plus *radii*, = "rays," in reference to the absence of any radial ornamentation.

LOCALITY DATA

The following are Tulane University fossil locality numbers. All are in the Chipola Formation, Calhoun County, Florida.

458. East bank of Chipola River, above Farley Creek (SW 1/4 Sec. 20, T1N, R9W).
550. East bank of Chipola River, 1 1/4 miles below "Bailey's Ferry" (NE 1/4 Sec. 20, T1N, R9W).
555. East bank of Chipola River, about 1000 ft. above mouth of Fourmile Creek (SW 1/4 Sec. 29, T1N, R9W).
821. Farley Creek, 0.1 mile east of bridge on Florida Highway 275 (SW 1/4 Sec. 21, T1N, R9W).
830. Tenmile Creek, at power line crossing about one mile west of Chipola River (SE 1/4 Sec. 12, T1N, R10W).
1048. Farley Creek, south bank, about 0.8 mile east of bridge on Florida Highway 275 (NE 1/4 Sec. 21, T1N, R9W).
1049. Farley Creek, south bank, about 1.0 mile east of bridge on Florida Highway 275 (NE 1/4 Sec. 21, T1N, R9W).
1050. Chipola River, west bank, immediately below power line crossing, and directly across river from loc. TU 554 (SW 1/4 Sec. 17, T1N, R9W).
1196. Farley Creek, north bank, about 0.8 mile east of bridge on Florida Highway 275 (NE 1/4 Sec. 21, T1N, R9W).

LITERATURE CITED

BALES, B. R., 1944, Florida Rock Dwellers: Shell Notes, v. 1, no. 7, p. 47-48.

DALL, W. H., 1898, Contributions to the Tertiary fauna of Florida: Wagner Free Inst. Sci., Trans., v. 3, pt. 4, p. i-viii, 571-947, pls. 23-25.

DALL, W. H., 1903, Contributions to the Tertiary fauna of Florida: Wagner Free Inst. Sci., Trans., v. 3, pt. 6, p. i-xiv, 1219-1654, pls. 48-60.

GARDNER, J. A., 1926-1950, The molluscan fauna of the Alum Bluff Group of Florida: U. S. Geol. Surv., Prof. Paper 142 (in 9 parts), 709 p., 62 pls.

MANSFIELD, W. C., 1937, Mollusks of the Tampa and Suwannee Limestones of Florida: Fla. Dept. Conservation, Geol. Bull. 15, 334 p., pls. A-D, 1-21, 2 text-figs., 2 tables.

MAURY, C. J., 1917, Santo Domingo type sections and fossils, Pt. 1; Mollusca: Bulls. Amer. Paleontology, v. 5, no. 29, p. 165-415, pls. 27-65, 1 map.

PERRY, L. M., 1940, Marine shells of the southwest coast of Florida: Bulls. Amer. Paleontology, v. 26, no. 95, 260 p., 39 pls.

SOLEM, ALAN, 1954, Living species of the pelecypod family Trapeziidae: Malac. Soc. London, Proc., v. 21, pt. 2, p. 64-83, pls. 5-7, 4 text-figs.

December 28, 1989

A NEW SPECIES OF *TRICHOTROPIS* (GASTROPODA:MESOGASTROPODA) FROM THE ESMERALDAS BEDS, ONZOLE FORMATION, NORTHWESTERN ECUADOR

WILLIAM D. PITT[1, 2] and LOIS J. PITT[2]

ABSTRACT

Only one species of *Trichotropis*, *T. pacifica* (Dall, 1908b), is known to occur in the Recent fauna of the Panamic-Galapagan faunal province of the Tropical East Pacific. A new species, *Trichotropis vokesae*, described herein from the Pliocene Esmeraldas beds, Onzole Formation, of northwestern Ecuador, is the first species of *Trichotropis* from the fossil record in the Tropical East Pacific.

INTRODUCTION

In the Tropical East Pacific, the family Trichotropidae is represented by one extant species, *Trichotropis pacifica* (Dall, 1908b), a deep-water species from Panama Bay, Panama. *Trichotropis vokesae*, n. sp., from the Pliocene Esmeraldas beds, Onzole Formation, near the village of Camarones, Esmeraldas Province, Ecuador, is the first member of the genus *Trichotropis* to be reported from the fossil record of the area.

In discussing the formational name to be used for the fossiliferous deposits at Quebrada Camarones, Vokes (1988, p. 3) notes that the name Esmeraldas Formation was proposed by Olsson (1942, p. 260) for the "highly foraminiferal, tuffaceous shales so extensively exposed along the coast of Esmeraldas and along the Esmeraldas river itself." Bristow and Hoffstetter (1977) confirmed the name "Esmeraldas Formation" of Olsson, 1942, but stated: "Olsson thought that the Esmeraldas Facies was equivalent to the Borbón Formation, differing only by the depositional zone, But in reality the Esmeraldas Formation is the Onzole Formation" (1977, p. 142, *translated*). The name "Onzole Formation" was first published by Stainforth (1948, p. 143) following an unpublished work of the I.E.P.C. by Smith (1946) (*fide* Bristow and Hoffstetter, 1977, p. 217). Bristow (1976, p. 193) claims that the Esmeraldas Formation was never properly defined by Olsson, and, as the name Onzole Formation has been widely used in Ecuador and accepted through common usage, it is best to retain the name Onzole Formation over Esmeraldas Formation. Vokes (1988, p. 4) finds it difficult to accept the name Onzole Formation for the mollusk-rich shallow-water gravity-flows of the upper part of the Onzole Formation and proposed usage of the term "Esmeraldas beds" for these deposits in northwestern Eucador. In this usage the Esmeraldas beds are equal to the upper Onzole Formation.

Whittaker (1988, p. 11) cited the age of the Onzole Formation in Esmeraldas Province (Borbón Basin) as between late Miocene (N 16) and late Pliocene (N 21); however, he (p. 12) cites the upper Onzole as being wholly of Pliocene age. Haman and Kohl (1986, p. 181) dated the "Esmeraldas beds" at Camarones as early Pliocene (N 18-19), which has been accepted by Vokes (1988, p. 4) and DuShane (1988, p. 51).

In discussing the deposition of the Esmeraldas Formation, Olsson (1964, p. 7) stated that the fauna of the "Esmeraldas beds" has many species closely allied to Caribbean taxa because the Isthmus of Panama was open, at least part of the time, during the deposition of the Esmeraldas beds. Olsson added that most of the species with deep-water characteristics were well preserved while the shallow-water forms showed signs of transport. He further observed (1964, p. 17): "The bathymetric range of most deep-sea mollusks is still poorly understood, and their distribution at varying depths may be as much dependent upon water temperature as on any other single factor."

In his systematic treatment of species, Olsson (1964, p. 112), noted that *Aforia ecuadoriana* Olsson, 1964, is remarkably similar to the Pleistocene to Recent *A. circinata* (Dall, 1873), which is found in the "Bering Sea; Alaska and Japan" (Abbott, 1974, p. 265). Vokes (1988, p. 9) included three muricid species in her Table 1, Group III, California-Northern Pacific:

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Ceratostoma notiale Vokes, 1988; *Pteropurpura marksi* Olsson, 1964; and *Pteropurpura ecuadoria* (Olsson, 1964). These three species from the Esmeraldas beds are either living in the more northern waters or have close allies there. In view of these species that either occur in deep-water or have northern cold-water allies it is not surprising to see occurring at Quebrada Camarones, *Trichotropis vokesae*, n. sp., a member of a genus which seems to be represented only in more northern or colder waters today.

SYSTEMATIC PALEONTOLOGY

Class GASTROPODA
Order MESOGASTROPODA
Superfamily CREPIDULOIDEA
Family TRICHOTROPIDAE Gray, 1850
Genus TRICHOTROPIS
Broderip and Sowerby, 1829

Trichotropis BRODERIP and SOWERBY, 1829, Zool. Jour., London, v. 4, p. 373.

Type species: *Turbo bicarinata* Sowerby, 1825, by subsequent design., Herrmannsen, 1849.

TRICHOTROPIS VOKESAE Pitt and Pitt, n. sp.
Pl. 1, figs. 1, 2a, 2b

Description: Shell thin; four whorls, plus a protoconch of about one and one-half smooth, rounded whorls with a blunt ending. Whorls straight-sided, slightly tapering inward, suture distinct. Spiral sculpture of two sharp carinae, one at the periphery and one near the base; basal carina adjacent to posterior side of suture. Axial sculpture of seven to nine irregular ribs extending from suture to suture, crossing the spiral carinae, and decreasing in number on later whorls, disappearing on last two whorls; otherwise only retractive growth lines. Aperture wide, somewhat triangular, truncated below basal carina. Body whorl slightly shorter than spire. Columella arcuate, narrow, ending with a small anterior notch. Umbilicus narrowly open, with a narrow groove to tip of columella.

Holotype: CASG 66058.01; height 24.0 mm, diameter 18.9 mm (pl. 1, fig. 1).

Paratype: CASG 66058.02; height 13.9 mm, diameter 10.0 mm (pl. 1, figs. 2a, 2b).

Type locality: TU 1397, "Esmeraldas beds"; Quebrada Camarones, cut-bank on east side of canyon, east of the village of Camarones, 20 km (by road) east of bridge over Rio Esmeraldas, Esmeraldas Prov., Ecuador.

Occurrence: Esmeraldas beds, Onzole Formation, Esmeraldas Prov., Ecuador.

Discussion: This new species is named for Emily Vokes of Tulane University. Emily and her husband Harold Vokes have assisted on collecting trips to Ecuador and have given us much encouragement to work on these unique fossil deposits of northwestern Ecuador.

Trichotropis vokesae is remarkably close to the Pliocene to Recent *Trichotropis bicarinata* (Sowerby, 1825), a boreal species ranging from the Queen Charlotte Islands, British Columbia, Canada, circumpolar to Newfoundland, Canada. *Trichotropis vokesae* differs from *T. bicarinata* in that the whorls taper inward rather than being perpendicular and the faces of the whorls are flat-sided rather than slightly concave. Also the distance between the carinae is greater in proportion to shell height and the columella is more arcuate and much narrower. The aperture also is shorter in proportion to shell height.

Specimens of *T. bicarinata* examined at LACM, CAS and USGS(MP) have five whorls plus the protoconch, whereas specimens of *T. vokesae* have four plus the protoconch; however, there is a difference in shell height among specimens of the two species examined. Broderip and Sowerby (1829, p. 374), in discussing *T. bicarinata*, noted that it has four or five whorls, which leaves the difference in the number of post-nuclear whorls of little importance. Specimens of *T. bicarinata* from Punuk Island, Bering Sea, Alaska (LACM 37-1) have axials on one or two post-nuclear whorls, otherwise all other specimens of *T. bicarinata* examined have no axials. The paratype of *T. vokesae* is smaller than the holotype and has axials on all whorls, the holotype does not have axials on the last two whorls. *Trichotropis pacifica* (Dall, 1908b), the only recorded member of the genus *Trichotropis* from the Tropical East Pacific, differs from *T. vokesae* is being tall, slender, cancellate with aperture narrow and about one-third of shell height; specimens of *T. vokesae* are short, robust, have two carinae, the aperture is large and about one-half of shell height.

Vokes (1988, p. 8) noted that the average living depth for the mollusks in the deposits at Quebrada Camarones was about 75 m but, as a result of gravity flows, the sediments at this locality were redeposited in perhaps 1,000 m of water. The depth

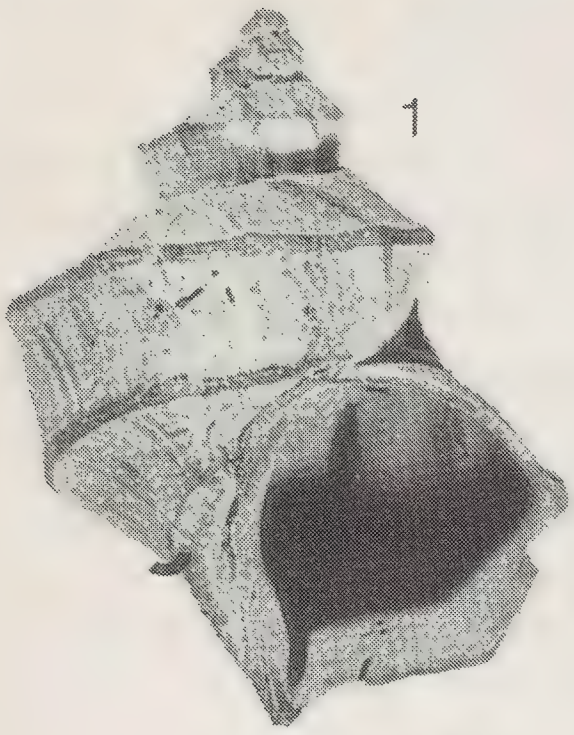

PLATE 1

Figures

1-2. *Trichotropis vokesae* Pitt and Pitt, n. sp.

1. CASG 66058.01 (holotype); height 24.0 mm, diameter 18.9 mm (X2).
2. CASG 66058.02 (paratype); height 13.9 mm, diameter 10.0 mm (X4).

Locality of both: TU 1397, Esmeraldas beds, Ecuador; Pliocene.

3-4. *Trichotropis bicarinata* (Sowerby).

3. LACM 37-1; height 39.3 mm, diameter 36.0 mm (X2).

Locality: Punuk Island, Alaska; Recent.

4. USNM 443585 (hypotype); height 26.6 mm, diameter 23.6 mm (X2).

Locality: Ocean Point, Coleville River, North Slope, Alaska; Pliocene.

range of the genus *Trichotropis* is from 1 to about 2,300 m.

There are 18 listed species in the genus *Trichotropis* occurring in the eastern Pacific and Caribbean, Recent and fossil, which are distributed in time and space as shown in Table 1.

The two Cretaceous species are included here only because they are similar and possibly represent ancestral forms. *Trichotropis obstricta* (White) is only similar in general outline. *Trichotropis mississippiensis* Sohl is very close in outline and does have two sharp carinae but the rest of the sculpture is quite different from *T. vokesae*.

The genus *Trichotropis* is usually found in either cold or deep water. Its presence together with the many warm-water elements of the Quebrada Camarones fauna is presumed to be due to mixing of the faunas by gravity flows. *Trichotropis vokesae* possibly represents a divergence from *T. bicarinata* and possibly originated in colder or more northern waters. The fact that forms of neither *T. vokesae* or *T. bicarinata* are found between Ecuador and the Queen Charlotte Islands may be due to either a paucity of fossil deposits on the Pacific coast of Central and South America, an artifact of collecting, or a lack of deep-water collecting of the Recent faunas. It is also possible that these two forms may have evolved separately and may not be closely related.

ACRONYMS

CAS	California Academy of Sciences
I.E.P.C.	International Ecuadorian Petroleum Company
LACM	Los Angeles County Museum of Natural History
TU	Tulane University
USGS(MP)	United States Geological Survey, Menlo Park

ACKNOWLEDGMENTS

Our thanks go to Emily and Harold Vokes of Tulane University for making their collections available and furnishing the specimens for this paper; to James Mc-

TABLE 1

T. mississippiensis Sohl, 1960	Cretaceous	Mississippi
T. obstricta (White, 1889)	Cretaceous	California
T. alienensis Effinger, 1938	Oligocene	Oregon, Washington
T. unicarinata Sowerby, 1866	Miocene	Oregon, Washington
T. tricarinata Addicott, 1970	Pliocene	Kern County, California
T. coronata Gould, 1860	Miocene-Recent	Oregon, Washington Arctic Ocean, Bering Sea
T. cancellata (Hinds, 1843)	Pliocene-Recent	Southern California Bering Sea to Oregon
T. migrans Dall, 1881	Recent	Cuba
T. nuda Dall, 1927	Recent	Florida and Gulf of Mexico
T. turrita Dall, 1927	Recent	Florida and Gulf of Mexico
T. bicarinata (Sowerby, 1825)	Recent	British Columba; Arctic Seas to Newfoundland
T. borealis Brod. and Sow., 1829	Recent	Europe, Arctic Seas to Bering Sea, Alaska, Japan
T. circumcinata (Dall, 1873)	Recent	Arctic Ocean, Bering Sea
T. insignis Middendorff, 1849	Recent	Bering Sea, Alaska, Japan
T. kelseyi Dall, 1908a	Recent	San Diego, California; Baja California, Mexico
T. kroyeri (Philippi, 1849)	Recent	Arctic Ocean, Bering Sea
T. lomana Dall, 1918	Recent	San Diego, California; Baja California, Mexico
T. pacifica (Dall, 1908b)	Recent	Panama Bay, Panama

Table 1. Distribution of species of *Trichotropis*.

Lean and Gale Sphon, Los Angeles County Museum of Natural History, for making their collections available and for assistance at the museum; to Lou Ella Saul, Los Angeles County Museum of Natural History, for furnishing information on Cretaceous species of *Trichotropis;* John Whittaker, British Museum (Natural History), for making museum collections and his collecting and research data available; to Roger Bristow, British Geological Survey, Exeter, England, for making his research and collecting data available; to Peter Rodda of the California Academy of Sciences and Charles Powell, United States Geological Survey, Menlo Park, for criticizing the manuscript; and Allan McMakin for photography of the type specimens.

BIBLIOGRAPHY

ABBOTT, R. T., 1974, American Sea Shells, Second Edition. New York, Van Nostrand Reinhold, 663 p., 24 pls., 6,405 figs.

ADDICOTT, W. O., 1970, Miocene Gastropods and Biostratigraphy of the Kern River area, California: U. S. Geol. Surv., Prof. Paper 642, p. i-iv, 1-174, pls. 1-21, text-figs. 1-11.

BRISTOW, C. R., 1976, The Daule Group, Ecuador (middle Miocene-Pliocene): Newsl. Stratigr., v. 5, nos. 2/3, p. 190-200, 2 text-figs.

BRISTOW, C. R., and ROBERT HOFFSTETTER, 1977, Ecuador: Lexique Stratigraphique International, Second Edition, v. 5, Amérique Latine, Fasc. 5A2, 410 p.

BRODERIP, W. J., and G. B. SOWERBY, 1829, Observations on new and interesting Mollusca contained, for the most part, in the Museum of the Zoological Society: Zool. Jour., London, v. 4, p. 359-379, pl. 9.

DALL, W. H., 1873, Preliminary descriptions of new species of Mollusca from the coast of Alaska with notes on some rare forms: Calif. Acad. Sci., Proc., v. 5, p. 57-62, pl. 2.

DALL, W. H., 1881, Reports on the results of dredging, under the supervision of Alexander Agassiz, in the Gulf of Mexico, and in the Caribbean Sea, 1877-79, by the United States Coast Guard Steamer "Blake"... XV. Preliminary report on the Mollusca: Bull. Mus. Comp. Zool., Harvard Univ., v. 9, no. 2, p. 33-144.

DALL, W. H., 1908a, Descriptions of new species of mollusks from the Pacific coast of the United States, with notes on other mollusks from the same region: U. S. Natl. Mus., Proc., v. 34, no. 1610, p. 245-257.

DALL, W. H., 1908b, Reports on the dredging operations off the west coast of Central America to the Galapagos, to the west coast of Mexico, and in the Gulf of California ... XIV. The Mollusca and Brachiopoda: Bull. Mus. Comp. Zool., Harvard Univ., v. 43, no. 6, p. 205-487, pls. 1-22.

DALL, W. H., 1918, Description of new species of shells, chiefly from Magdelena Bay, Lower California: Biol. Soc. Washington, Proc., v. 31, p. 5-8.

DALL, W. H., 1920, Pliocene and Pleistocene fossils from the Arctic Coast of Alaska and auriferous beaches of Nome, Norton Sound, Alaska: U. S. Geol. Surv., Prof. Paper 125, p. 23-37, pls. 5-6.

DALL, W. H., 1921, Summary of the marine shellbearing mollusks of the northwest coast of America, from San Diego, California, to the Polar Sea: U. S. Natl. Mus., Bull. 112, 217 p., 22 pls.

DALL, W. H., 1927, Small shells from dredgings off the southeast coast of the United States by the United States Fisheries Steamer "Albatross" in 1885 and 1886: U. S. Natl. Mus., Proc., v. 70, art. 18, no. 2667, p. 1-134.

DUSHANE, HELEN, 1988, Pliocene Epitoniidae of the Esmeraldas beds, northwestern Ecuador: Tulane Stud. Geol. Paleont., v. 21, p. 51-58, 12 figs.

EFFINGER, W. L., 1938, The Gries Ranch Fauna (Oligocene) of western Washington: Jour. Paleontology, v. 12, p. 355-390, pls. 45-47.

GOULD, A. A., 1860, Descriptions of shells collected in the North Pacific Exploring Expedition under Captains Ringgold and Rodgers: Boston Soc. Nat. Hist., Proc., v. 7, p. 323-336.

HAMAN, DREW, and BARRY KOHL, 1986, Early Pliocene *Montfortella* (Foraminiferida) from Ecuador: Tulane Stud. Geol. Paleont., v. 19, p. 181-183, 1 pl.

HINDS, R. B., 1843, On new species of shells collected by Sir Edward Belcher, C. B: Zool. Soc. London, Proc., v. 11, p. 17-19.

MACPHERSON, ELIZABETH, 1971, The Marine Molluscs of Arctic Canada, (Prosobranch Gastropods, Chitons and Scaphopods), Natl. Mus. Nat. Sci., Publ. in Biology, Oceanography; Oceanography No. 3: Natl. Mus. Canada, Ottawa, vi-viii, 144 p., 7 pls., 54 maps, 3 figs.

MIDDENDORFF, A. T. VON, 1849, Beiträge zu einer Malacozoologia Rossica. St. Petersburg, Pt. 2, 187 p.; Pt. 3, 99 p., 21 pls.

OLSSON, A. A., 1942, Tertiary deposits of northwestern South America and Panama: Eighth American Sci. Cong., Proc., v. 4, p. 231-287.

OLSSON, A. A., 1964, Neogene Mollusks from northwestern Ecuador. Paleontological Research Institution, Ithaca, New York, 256 p., 38 pls.

PHILIPPI, R. A., 1849, Centuria tertia testaceorum novorum: Zeit. Malak., Jahrg., v. 5, no. 11, p. 161-176.

SMITH, J. A., 1946, Informes geológicos y geofísicos de la International Ecuadorian Petroleum Co.: Dir. Min. Petrol., Minist. Econ., Quito (Unpublished report).

SOHL, N. F., 1960, Archeogastropoda, Mesogastropoda and stratigraphy of the Ripley, Owl Creek, and Prairie Bluff formations: U. S. Geol. Surv., Prof. Paper 331-A, p. 1-151, 18 pls., 11 text-figs.

SOWERBY, G. B., 1825, A catalogue of the shells contained in the collection of the late Earl of Tankerville. London, i-vii, 1-92, app. p. i-xxxiv, 9 pls.

SOWERBY, G. B., JR., 1866, Thesaurus Conchyliorum, or monographs of genera of shells, edited by G. B. Sowerby, Jr. London, v. 3, pts. 24, 25, p. 272-331, pls. 266-290.

STAINFORTH, R. M., 1948, Applied micropaleontology in coastal Ecuador: Jour. Paleontology, v. 22, p. 113-151.

VOKES, E. H., 1988, Muricidae (Mollusca:Gastropoda) of the Esmeraldas beds, northwestern Ecuador: Tulane Stud. Geol. Paleont., v. 21, p. 1-50, 6 pls., 14 text-figs.

WEAVER, C. E., 1942, Paleontology of the marine Tertiary formations of Oregon and Washington: Univ. Washington [Seattle], Publ. Geol., v. 5, pts. 1-3, 789 p., 104 pls.

WHITE, C. A., 1889, On invertebrate fossils from the Pacific coast: U. S. Geol. Surv., Bull. 51, 102 p., 14 pls.

WHITTAKER, J. E., 1988, Benthic Cenozoic Foraminifera from Ecuador. British Museum (Natural History), London, xi + 194 p., 25 pls., 16 text-figs.

December 28, 1989

NOTES ON THE FAUNA OF THE CHIPOLA FORMATION-XXXII
A NEW SPECIES OF THE GENUS *CYMATIUM* (MOLLUSCA: GASTROPODA)

GARY W. SCHMELZ
NAPLES, FLORIDA

While collecting fossil mollusks along Tenmile and Farley Creeks in Calhoun County, Florida, this investigator discovered a number of specimens of a new species of *Cymatium*. This species and many other unusual forms were concentrated in a highly fossiliferous layer of reddish brown earth that directly overlies a more compact deposit of gray siliceous sediment. A total of four nearly complete specimens of the *Cymatium* were obtained from the south side of Tenmile Creek at Tulane collection site 951 (TU 951). Two additional specimens were collected on the north side of Tenmile Creek at the power line near TU 1098. One of these specimens is complete and the second consists of a large fragment of the body whorl. Another large fragment of the body whorl of this species was collected from the south side of Farley Creek at TU 819. This fragment measures 40 mm from the end of the siphonal canal to the shoulder of the body whorl and is larger than any of the other specimens. An additional example of this species was also collected by Emily Vokes, on Tenmile Creek at TU 546.

CYMATIUM (GUTTURNIUM) RITTERI
Schmelz, n.sp.
Text figs. 1, 2

Diagnosis: Shell is triangular shaped. A small portion of the protoconch, remaining in the holotype, is smooth and glossy, and becomes abruptly sculptured with weak, raised cords and axial ridges about halfway through its development. The surface of the last four and one-half teleoconch whorls is covered with gradually more pronounced raised cords and axial ridges. On the teleoconch whorls all of the spiral cords cross over the axial ridges. Fine vertical growth lines also cross over the cords and intervening spaces, giving the shell a faint cross-hatched appearance. The growth lines are most prominent on the spiral cords. On the penultimate whorl there are seven to eleven prominent axial ridges; anterior to the suture there are three narrow spiral cords followed by two to three alternating pairs of wide and narrow ones. On the body whorl there are two prominent corrugated axial varices, which are separated by two to three axial ridges. Anterior to the body whorl suture are three to four narrow spiral cords. These are followed by alternating pairs of wide and narrow spiral cords. Aperture elongate-oval; with numerous plicae extending across the parietal wall. The outer lip of the aperture is crenate and has a set of three short teeth near the anal area followed by six pairs of short teeth, evenly spaced along the remainder of the opening. The siphonal canal is long and slender with the anterior half bent dorsally.

Holotype: USNM 445741; height 30 mm, diameter 16.5 mm.

Type locality: TU 951, south bank of Tenmile Creek, about 1 1/2 miles west of Chipola River (SE 1/4 Sec. 12, T1N, R10W), Calhoun County, Florida.

Paratype: USNM 445742; height 39 mm, diameter 20 mm; locality TU 546, Tenmile Creek, Calhoun County, Florida.

Discussion: A review of the literature reveals that this is the first species of *Cymatium* to be recognized from early Miocene deposits; however, Maury (1925) described a species of *Cymatium* from the early Miocene Pirabas Formation in Brazil as *Murex williamsi*. The species described here differs from Maury's specimen in that it has a more angulate body shape and the penultimate whorl has fewer axial ridges (seven to eleven *vs.* sixteen). In Maury's specimen all of the teleoconch whorls are sculptured with spiral cords of unequal thickness but in *Cymatium ritteri* there are three to four narrow cords anterior to the suture followed by alternating cords of unequal thickness. Maury (1925) also noted that the growth lines on her specimen are most apparent in the intervals between the cords but in the new species the growth lines are very faint in the interval between the cords and most prominent on the cords.

Representatives of the genus *Cymatium* have been reported from a number of different Cenozoic deposits. *Cymatium ogygium* Woodring (1959, p. 204, pl. 27, figs. 4,6) was described from the south coast of Pato Horqueto Island in the Panama Canal Zone in beds of early Oligocene age and is the oldest species of this genus found in the Caribbean region. A related species, *Cymatium amnicretum* MacNeil, 1984, was reported from deposits of a similar age by MacNeil and Dockery (1984, p. 116, pl. 18, figs. 4, 5). The latter species is probably also related to *Guttur-*

nium gracile gurabonicum Maury (1917, p. 107, pl. 17, fig. 10) from the late Miocene Gurabo Formation of the Dominican Republic.

In Florida, Mansfield (1930, p. 94, pl. 12, fig. 10) described a single immature specimen as *Cymatium floridanum,* from the early Pliocene deposits of the Jackson Bluff area. A number of specimens of this species have since been obtained by collectors from the APAC pit in Sarasota (personal observation).

There have been numerous reports of *Cymatium* in the Pleistocene of the Caribbean area. *Cymatium pileare* (Linné, 1758) was collected from Pleistocene sediments of Costa Rica by Gabb (1881) and by Weisbord (1962) from Barbados and the Panama Canal Zone. Weisbord (1962) also identified the subspecies, *Cymatium pileare martinianum* (d'Orbigny, 1846) from northern Venezuela as well as *Cymatium parthenopeum* (Von Salis, 1793). This latter species has also been reported from the upper Miocene of Calolira in Europe by Watson (1886). Weisbord was the first to identify *Cymatium krebsii* Mörch, 1877, from Pleistocene deposits in northern Venezuela. Hoerle (1970) reported *Cymatium cingulatum* (Lamarck, 1822) from the Bermont beds at the Belle Glade Rock Pit.

LOCALITY DATA

546. Chipola Fm., Tenmile Creek, about 1 3/4 miles west of Chipola River (NE 1/4 Sec. 12, T1N, R10W), Calhoun Co., Florida (= USGS 2212, "one mile west of Bailey's Ferry").
819. Chipola Fm., Farley Creek, 0.2 mile west of bridge of Florida Highway 275 (SW 1/4 Sec. 21, T1N, R9W), Calhoun Co., Florida.
951. Chipola Fm., Tenmile Creek, about 1 1/4 miles west of Chipola River (SE 1/4 Sec. 12, T1N, R10W), Calhoun Co., Florida.
1098. Chipola Fm., Tenmile Creek, south bank just east of power line crossing (SE 1/4 Sec. 12, T1N, R10W), Calhoun Co., Florida.

LITERATURE CITED

GABB, W. M., 1881, Descriptions of new species of fossils from the Pliocene clay beds between Limon and Moen, Costa Rica, together with notes on previously known species from there and elsewhere in the Caribbean: Acad. Nat. Sci. Philadelphia, Jour., (Ser. 2), v. 8, p. 349-380, pls. 45-47.

HOERLE, S. E., 1970, Mollusca of the "Glades" unit of southern Florida; Part II: List of molluscan species from the Belle Glade Rock Pit, Palm Beach County, Florida: Tulane Stud. Geol. Paleont., v. 8, no. 2, p. 56-68.

MACNEIL, F. S., and D. T. DOCKERY, III, 1984, Lower Oligocene Gastropoda, Scaphopoda, Cephalopoda of the Vicksburg Group in Mississippi: Miss. Dept. Nat. Res., Bur. Geol., Bull. 124, 415 p., 72 pls., 16 textfigs.

MANSFIELD, W. C., 1930, Miocene gastropods and scaphopods of the Choctawhatchee Formation of Florida: Florida Geol. Surv., Bull. 3, 185 p., 21 pls.

MAURY, C. J., 1917, Santo Domingo type sections and fossils, Pt. 1: Mollusca: Bulls. Amer. Paleontology, v. 5, no. 29, p. 165-415, pls. 27-65, map.

MAURY, C. J., 1925, Fosseis Terciarios do Brasil: Serv. Geol. Min. Brasil., Mon. 4, 665 p., 24 pls.

WATSON, R. B., 1886, Report on the Scaphopoda and Gastropoda collected by H.M.S. *Challenger,* Zoology, v. 15, p. 1-756, pls. 1-50.

WEISBORD, N. E., 1962, Late Cenozoic gastropods from northern Venezuela: Bulls. Amer. Paleontology, v. 42, no. 193, 672 p., 48 pls.

WOODRING, W. P., 1959, Geology and paleontology of the Canal Zone and adjoining parts of Panama; Description of Tertiary mollusks (Gastropods: Vermetidae to Thaididae): U.S. Geol. Survey, Prof. Paper 306-B, p. 147-239, pls. 24-38.

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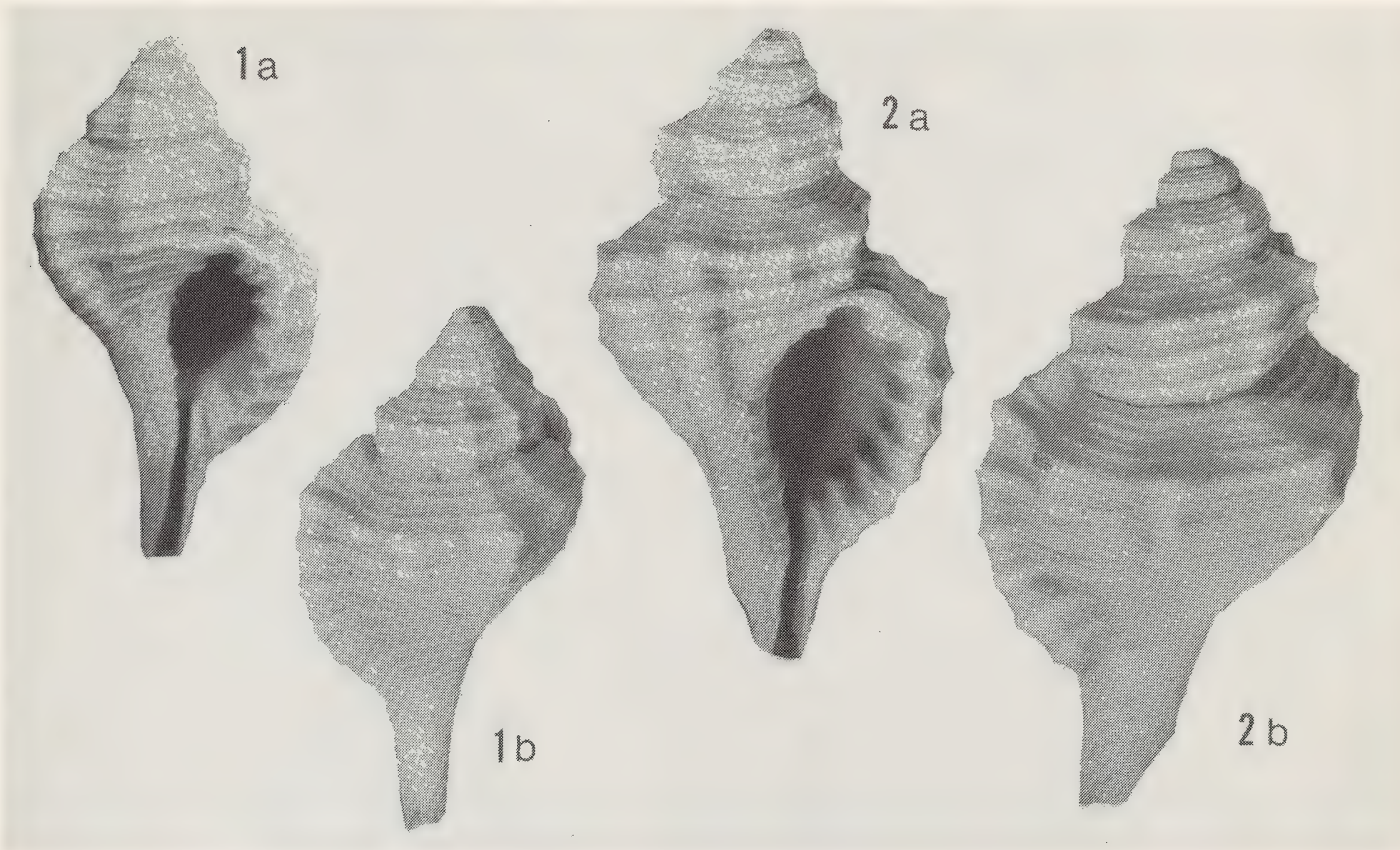

Text fig. 1, USNM 445741 (holotype); height 30 mm, diameter 16.5 mm; locality TU 951.
Text-fig. 2, USNM 445742 (paratype); height 39 mm, diameter 20 mm; locality TU 546.
(Both X 1 1/2)

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Burnett Smith was descended from a long line of central New York settlers, dating back to the earliest Dutch inhabitants. In 1907 he became instructor and later Professor of Paleontology at Syracuse University. Upon his retirement in 1928, he worked as a geologist for the New York State Museum and was a charter member of the Paleontological Research Institute in Ithaca, serving as its President in 1937-1939. Although many of his publications reflect his interest in the geology of New York, it is for his work on marine gastropods, fossil and Recent, that he is best remembered, especially his pioneering studies on the taxonomic value of their protoconchs. (*From* K. V. W. Palmer, 1960, Geological Society of America, Proceedings for 1959)

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See plate Expl -

CENOZOIC MURICIDAE OF THE WESTERN ATLANTIC REGION PART VIII – *MUREX* S.S., *HAUSTELLUM*, *CHICOREUS*, AND *HEXAPLEX*; ADDITIONS AND CORRECTIONS

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CENOZOIC MURICIDAE OF THE WESTERN ATLANTIC REGION PART VIII – *MUREX* S.S., *HAUSTELLUM*, *CHICOREUS*, AND *HEXAPLEX*; ADDITIONS AND CORRECTIONS

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I. ABSTRACT

A total of 165 names have been applied to western Atlantic species referred herein to the muricid genera *Murex* s.s., *Haustellum*, *Hexaplex*, and *Chicoreus*, including its four subgenera: *Chicoreus* s.s., *Siratus*, *Phyllonotus*, and *Naquetia*. Of these, 101 are valid and are treated systematically; however, the two species of *Murex* s.s. present are only questionably referred to the western Atlantic fauna. Of the remaining 99 valid species there are 16 of *Haustellum*, 22 of *Chicoreus* s.s., 28 of *Siratus*, 19 of *Phyllonotus*, one of *Naquetia*, and 13 of *Hexaplex*. Of these 99 species, eight occur in Eocene beds, with the oldest known from the Middle Eocene Weches Formation of Texas; seven occur in Oligocene beds; 31 in Miocene formations; and 46 in Plio-Pleistocene strata. There are 42 species in the Recent fauna, but only 18 are confined to the Recent, the remainder are both living and fossil. Of this number 9 are new species and are named herein. They are: *Haustellum mimiwilsoni*, from the Cumaná Formation of Venezuela and the Río Banano Formation of Costa Rica; *Chicoreus (Chicoreus) jungi*, from the Grand Bay Formation, Carriacou, West Indies; *Chicoreus (Chicoreus) veronica* and *Chicoreus (Siratus) habros*, from the Agueguexquite Formation, Mexico; *Chicoreus (Siratus) miltos*, from the Concepcion Inferior Formation, Mexico; *Chicoreus (Siratus) sextoni* and *Chicoreus (Phyllonotus) louisae*, from the Chipola Formation, Florida; *Chicoreus (Phyllonotus) initialis*, from the Weches Formation, Texas; and *Hexaplex isthmicus*, from the Gatun Formation, Panama.

II. INTRODUCTION

The first part of this study appeared in 1963 as a monograph on the genus *Murex sensu stricto*. In the succeeding years six additional parts appeared; the last, that on the genera *Calotrophon* and *Attiliosa*, was published in 1976. It was my plan at the conclusion of the study of the subfamily Muricinae, which was completed with this latter part, to present a part VIII – Summary and Corrections for the entire subfamily, before embarking upon the subfamilies Muricopsinae and Ocenebrinae.

However, in 1976, my husband Harold and I made the first of many collecting trips to the Dominican Republic. This first visit resulted in so many new taxa that a decision was made to do a separate paper on the Dominican muricids, in which these taxa would be described before being incorporated into the proposed Summary. Little did I suspect that this project would require 13 years and culminate finally in a different Part 8 – the *Neogene Paleontology of the northern Dominican Republic* (Vokes, 1989b), which forms only a portion of a major study on the fauna of the Mio-

Pliocene of that country. It is fortunate that I waited, for in the Dominican report 32 species of Muricinae are treated, of which 13 are described therein. Nineteen of the 32 are species of the genera covered in the present work; the remainder will be treated in subsequent parts.

When Part I of *Cenozoic Muricidae* was published in 1963, the Tulane Geological Collections consisted of material from only 555 localities; today the localities number over 1500. The Cenozoic localities have increased from 160 to more than 1000. Recent collecting localities represented have grown from 42 to nearly 600. Thus, a great deal of new information has been accumulated.

Much of this has been published already, as in the case of the Dominican Republic material. I have described new species of *Murex* (1967a), and new species of *Chicoreus* (1974a). Petuch (1987, and elsewhere) has named several new forms. But the time has come to assimilate this scattered information into one (currently) complete summary of all species of Muricinae, fossil and Recent, presently known from the western Atlantic region.

In addition to new material, several taxonomic changes shifting species into different genera, and genera into different subfamilies have been made. These changes will be discussed with the relevant taxonomic groups. A general reference chart appears below as Table 1, to indicate where supraspecific taxa are currently placed.

III. STRATIGRAPHIC CORRELATION

In the interval since this series began great strides have been made in long-range geologic correlation by means of planktic foraminifera and calcareous nannofossils. Rather than repeat the discussion for every species that occurs in these formations it seems more useful to list all of them together with the most recent information on correlations. It should be noted that the formations discussed here are only those in which species of Muricinae occur. This is *not* intended to be a definitive analysis of all Neogene formations in the western Atlantic. For the best synthesis of the stratigraphy (Upper Cretaceous to Holocene) of the Atlantic and Gulf Coastal Plain the reader is referred to Carter (1984).

Unfortunately, there is a recurring problem in that the formations in which mollusks are most abundant are those nearshore facies where the planktic foraminifera and calcareous nannofossils are least likely to be encountered. In the deep-water facies where the latter are most abundant, mollusks are almost nonexis-

TABLE 1

Genera of the subfamily Muricinae that occur in the western Atlantic.

Covered in this paper

Murex s.s. [?none in the Western Atlantic]

Haustellum

Chicoreus
  Chicoreus s.s., *Siratus*, *Phyllonotus*, *Naquetia*

Hexaplex

To be covered in next paper

Pterynotus
  Pterynotus s.s., *Pterochelus*, *Purpurellus*

Poirieria
  Poirieria s.s., *Paziella*, *Pazinotus*, *Flexopteron*

Aspella

Dermomurex
  Dermomurex s.s., *Takia*, *Gracilimurex*, *Trialatella*

Calotrophon

Attiliosa

tent. Thus, there are many formations for which we have no better correlation data than we did 30 years ago.

In general, there has been little change in the stratigraphic assignments of the Paleogene formations. An excellent correlation chart for the Paleogene of the Gulf Coastal Plain has been given by Dockery (1980, pp. 22-23). The Paleocene, Eocene, and Oligocene units are essentially unchanged. However, the Silverdale beds of North Carolina, originally placed in the Early Miocene are now placed in the latest Oligocene (Chickasawhayan Stage), as is the Tampa Limestone of peninsular Florida.

The Chipola Formation of northwestern Florida was the subject of a detailed study by Akers (1972), who determined that the formation is Burdigalian (planktic zones N.4-8) rather than Helvetian as I once suggested (Vokes, 1965b, p. 205). The resemblances to the Helvetian beds in southern France are evidently due more to ecology than time. The Cantaure Formation of Venezuela monographed by Jung (1965) also has been dated as Burdigalian (Hunter and Bartok, 1974, p. 147) and is correlated with the Quiroz fauna of the La Rosa Formation (= Agua Clara Formation; see Bolli, 1972).

The Pirabas Limestone of Brazil has been referred to ages ranging from Cretaceous (resulting in citations of the genus *Murex* as dating back to the Cretaceous) to Middle Miocene. In a recent discussion of the problem (Vokes, 1989b, p. 28), I concluded that these beds probably correlated with the Tampa Limestone and thus were Early Miocene, possibly correlating with the Baitoa Formation of the Dominican Republic. However, if the Tampa should prove to be older, then it is possible that the Pirabas also is Late Oligocene.

Once considered the most widespread of all Neogene horizons, most of the "Middle Miocene" formations throughout the area are now dated as Pliocene. In large measure the reason for older dates for many of the younger Neogene formations is their supposed correlation with the "Middle Miocene" Bowden fauna of Jamaica. Because this was the first "modern" faunal study and because Woodring (1928) did such a thorough job, it became the standard by which all others were measured. Unfortunately, due to lack of knowledge of the living Caribbean fauna, in particular deeper water forms, the Lyellian technique of percent of living species gave an age that was older. More recent planktic evidence places the Bowden shell bed in the basal Pleistocene (N.22) rather than Middle Miocene, as it was originally considered by Woodring (see Lamb and Beard, 1972, p. 32).

The Shoal River Formation of northwestern Florida is still placed in the Middle Miocene (Carter, 1984, zones N.8-13). The Yellow River Formation (formerly the "*Yoldia* Faunizone" of the Choctawhatchee Formation, now Group) has been demonstrated to be Middle Miocene (N.14) on the basis of the rich planktic fauna (Akers, 1972, p. 12). In the Atlantic Coastal Plain section the Calvert, Choptank, and St. Marys formations of Maryland and northeastern Virginia, and the Kirkwood Formation of New Jersey, are still considered to be Middle Miocene (Blackwelder and Ward, 1976; Gibson, 1983). In the Caribbean, the Grand Bay Formation of the island of Carriacou has been shown by Robinson and Jung (1972, p. 124) also to be of Middle Miocene age.

Most formations formerly placed in the Late Miocene are now Pliocene and in the U.S. only the Red Bay Formation of the Choctawhatchee Group (Akers, 1972, p. 13), the St. Marys Formation of southeastern Virginia (= Eastover Formation: Ward and Blackwelder, 1980) and North Carolina (Gibson, 1983) remain in the Late Miocene.

The Tubará Group of Colombia is no longer considered to be Early to Late Miocene but is probably Late Miocene to Early Pleistocene in age. There is no positive information but the "*Murex mississippiensis*" of Anderson (1929, p. 139) from the lower Tubará is *Cantharus scrupeus* Olsson, 1964, described from the Early Pliocene Esmeraldas Formation of Ecuador (N.19), and various species from the "upper Tubará" correlate with species from the Pinecrest (mid-Pliocene) and Moín (Early Pleistocene) beds of other areas. Incidentally, although the original spelling for the group was as "Tuberá" (Anderson, 1929, p. 92), the correct spel-

ling for the name of this village in Colombia on the road between Barranquilla and Cartegena is Tubará.

The most definitive work to date on correlations in the western Atlantic has been that done in the Dominican Republic (Saunders, Jung, and Biju-Duval, 1986). Their paper demonstrates that the Baitoa Formation is Late Early Miocene (= Chipola Formation), the Cercado is Late Miocene, and the Gurabo is latest Miocene and Early Pliocene.

The Mao Formation in the Dominican Republic is a deep-water unit that marks the last major transgression over the entire area. There are numerous formations throughout the western Atlantic that correlate with this mid-Pliocene aged (N.20) unit. In southern Florida the Pinecrest Beds* have become much better known as the result of major new excavations in the vicinity of Sarasota. These beds, dated as N.20 (Akers, 1974) are essentially the same age as the more northerly Jackson Bluff Formation of the Choctawhatchee Group, which in turn is the southern equivalent of the Atlantic Coastal Plain Yorktown and Duplin formations (for all of these see Akers, 1972, 1974, and Akers and Koeppel, 1973). A great deal of "fine-tuning" has been done on the exact correlation of the units in the Atlantic Coastal Plain by various authors; for a summary the reader is referred to Blackwelder (1981), Carter (1983, 1984), Gibson (1983), and Hazel (1983).

In the Isthmus of Tehuantepec of southern Mexico there are several "formations," which represent the shoaling of the Salina Basin. Originally described as being of ages ranging from Early Oligocene to Late Miocene, they are now considered to be Middle Miocene (La Laja, Deposito, and Encanto formations), Late Miocene (Medias Aguas Beds of Akers, 1980), and Early to Middle Pliocene (Concepcion, Filisolo, and Agueguexquite beds), ranging from N.19 at the bottom to N.20 at the top (Kohl, 1985). There is a slight difference in the dating of the units near the coast studied by Kohl (1985) and the more inland outcrops studied by Akers (1979, 1980), but as our fossils come from the inland areas, Akers' intrepretation is followed.

In Panama there is still no positive dating of the Gatun Formation but in Costa Rica the "upper Gatun" of Olsson (1922, p. 182) is now called the Río Banano Formation and has a good N.20 fauna (Akers, personal communication). The Gatun has been correlated with the Urumaco Formation of Venezuela, considered by Bolli (1972, fig. 3) as Late Miocene. It was also correlated with the Angostura Formation of Ecuador by Olsson (1964, p. 8), which is dated by Whittaker (1988, p. 10) as probably Late Miocene. However, it is my opinion that the resemblance between the Angostura and the Gatun is due more to facies than age (see Vokes, 1989c, p. 108), and the Gatun is probably Early Pliocene in age.

In Venezuela Bolli (1972, fig. 3) has also dated the Punta Gavilan Formation as mid-Pliocene. The Cabo Blanco Group, considered by Weisbord (1962) as Late Miocene to Pliocene in age is now dated as basal Pleistocene, on the basis of the appearance of the foraminifer *Globorotalia truncatulinoides,* and correlated with the Cumaná Formation. The Cumaná has been considered by most workers to be Late Pliocene; however, in the *Lexico Estratigrafico de Venezuela* (1970, p. 187) the age was moved up to Early Pleistocene on the grounds that the zone of *Globorotalia truncatulinoides* (N.21-23) has been reassigned to the Pleistocene. There is some question as to the validity of this placement and these units will be classified as "Plio-Pleistocene" herein.

The Caloosahatchee Formation continues to be a problem, largely because it spans the line arbitrarily taken to be the boundary between the Pliocene and the Pleistocene. Authors have been arguing over the exact placement of this boundary for years. The general consensus today is that the boundary should be placed between planktic zones N.21 and 22, or between the Piacenzian and the Calabrian. The age of the Caloosahatchee is from 1.5 to 2.5 m.y.; thus, if the boundary is placed at 1.8 m.y. (after Blackwelder, 1981, p. 9),

*Petuch (1986) considers that the name "Pinecrest" is preoccupied by an earlier use of the name for a Triassic formation in Utah. As pointed out in Vokes (1988, p. 2, footnote), this is irrelevant and the name "Pinecrest Beds" will continue to be used herein.

the older portions are Late Pliocene (N.21) but the upper parts are Early Pleistocene (N.22), and the exact age of this unit varies from locality to locality (see Hazel, 1983, figure 4). What has been called the Waccamaw Formation in North and South Carolina has the same problem with age. The lower beds, now termed the Bear Bluff Formation (DuBar, 1974), are Late Pliocene and the upper beds are Early Pleistocene (see Akers, 1972, p. 40), correlating with the Caloosahatchee Formation at its type locality on the Caloosahatchee River (= locality TU 536). The type locality of Blackwelder's (1981) Windyan Substage (Early Pleistocene) is essentially the same as our locality TU 558 and the muricid fauna is identical to that of the typical Caloosahatchee Formation.

If the upper portions of the Caloosahatchee and Waccamaw formations are N.22, then they correlate with the Moín Formation in Costa Rica, which Akers (1972) dated as N. 22. However, his samples were taken at approximately 40 meters above sea-level (TU locality 954). Later, we collected at about 60 meters above sea-level (TU 1240) and Dr. Akers dated this material (personal communication) as N.23 or mid-Pleistocene. Therefore, the lower portions of the Moín are believed to correlate with the Caloosahatchee and the upper portions would correlate with the Bermont Formation (= unnamed post-Caloosahatchee formation of Vokes, 1963a, 1965a, 1967b, etc.) in southern Florida.

IV. ACKNOWLEDGMENTS

To thank all of the people who have assisted in this study, which is the distillation if not the culmination of a 30 year career, I would have to thank everyone I know. Therefore, I would like to begin by expressing my gratitude to all of my colleagues, professional and amateur, who, through the years, have provided information, specimens, and hospitality in their homes and museums. But for the preparation of this paper, I do want to add a special note of thanks to certain individuals. First among these would be the late Joseph H. Peck and his successors, Liz Nesbitt and David R. Lindberg, who lent to me (back in 1966!) all of the Caribbean fossil muricid material in the collections of the Museum of Paleontology, University of California, Berkeley, and have never once suggested that I return it. I hope this paper justifies their trust in me. Thanks also go to Peter Jung, Naturhistorisches Museum, Basel, Switzerland, for his kindness in allowing me to examine the collections under his care as well as for the loan of the type specimen of *Chicoreus (Chicoreus) jungi,* and to Louise Compton, of Marietta, Georgia, who graciously gave me two specimens of *Chicoreus (Phyllonotus) louisae,* when I asked to borrow them. Susan Stephens, Sanibel, Florida, has been extremely helpful, providing specimens from and information concerning the Pliocene outcrops near Sarasota, Florida. Kevan and Linda Sunderland, Sunrise, Florida, provided much data on the habitats of living western Atlantic species. Several persons have donated or loaned specimens, either as types or figured specimens: Thomas G. Andrews, Jr., Nacogdoches, Texas; Jack Gibson-Smith, formerly of Caracas, Venezuela, now Surry, England; Jose and Marcus Coltro, of Sao Paulo, Brazil; James Allen, Alexandria, Louisiana, and Paul Drez, Albuquerque, New Mexico. As always, the members of the staff of the U. S. National Museum (Thomas R. Waller and Warren Blow, Paleobiology; M. G. Harasewych, Recent Mollusca) and the Academy of Natural Sciences of Philadelphia (George M. Davis and David S. Wiedner) have been very generous in lending specimens. Hubert C. Skinner took on the formidable task of editing the manuscript (however, I hold him blameless for any errors that have crept through). Finally, my deepest thanks go to my husband Harold E. Vokes, field assistant, photographer, curatorial aid, and listener.

V. SYSTEMATIC DESCRIPTIONS

In general, information on synonymies and localities given in earlier parts of this series will not be repeated. Only references that have appeared since the original treatment, or citations that have changed in some way will be included. Most references to Recent occurrences will not be included, except for the ones in two important books on the Muricidae

(Radwin and D'Attilio, and Fair), which both appeared in 1976. This will not be absolute but in the interest of brevity it seems of little value to repeat material that is unchanged.

Superfamily MURICACEA Rafinesque, 1815

Family MURICIDAE Rafinesque, 1815

Subfamily MURICINAE Rafinesque, 1815

Genus MUREX Linné, 1758

Murex LINNÉ, 1758, Systema Naturae, ed. 10, p. 746.

Type species: *Murex tribulus* Linné, 1758, by subsequent designation, Montfort, 1810.

Discussion: For a discussion of this genus, its synonyms, biology, anatomy, and taxonomy, the reader is referred to Ponder and Vokes (1988).

In my original treatment of what was then called the genus *Murex* s.s. (Vokes, 1963a) there were 19 species in the fossil record of the western Atlantic. Of that number, one (*Murex vaughani* Maury, 1910) is now placed in *Dermomurex (Takia),* one (*Murex williamsi* Maury, 1925) is a *Cymatium* (Schmelz, 1989, p. 137; see pl. 12, figs. 5, 6 herein), two are synonyms of other species, and the remaining fifteen taxa are almost equally divided between the genus *Haustellum* and the subgenus *Chicoreus (Siratus).* In the 1963 work I considered all species with three spinose varices and a long siphonal canal as "*Murex* s.s." Within this group I separated two subgroups (without taxonomic rank): the "Indo-Pacific" form, with a straight siphonal canal; and the "Western Atlantic" form, in which the canal is deflected dorsally.

Very soon, as my continuing study of the Muricidae progressed, I realized that the "Western Atlantic" forms were better placed in *Chicoreus (Siratus)* and in Part II of the series this shift was made (Vokes, 1965a, pp. 183, 195). However, not until after extensive work on the Recent Indo-Pacific members of the genus *Murex* (Ponder and Vokes, 1988) did it become obvious to me that the "Indo-Pacific" forms with straight siphonal canals were better placed in *Haustellum.* Thus, with the two possible exceptions discussed below, there are *no* members of *Murex* s.s. in the western Atlantic fauna, fossil or Recent.

Subgenus MUREX sensu stricto

MUREX (MUREX) SURINAMENSIS Okutani

Murex (Murex) surinamensis OKUTANI, 1982, Venus, Jap. Jour. Malac., v. 41, no. 2, p. 109, pl. 1, figs. 1-3, text-figs. 1 (protoconch), 2 (operculum); OKUTANI, 1983, Crust. Moll. Suriname and French Guiana, p. 273 (figured).

Murex surinamensis Okutani. PONDER and VOKES, 1988, Rec. Australian Mus., Suppl. 8, p. 12, text-fig. 12 (holotype).

Holotype: Natl. Sci. Mus. Tokyo, NSMT-Mo 60021; height 98.5 mm, diameter 29.3 mm.

Type locality: Lat. 10°46'N, Long. 61°32'W, 94 meters. (This point is approximately Port of Spain, Trinidad.)

Occurrence: Recent only.

Discussion: Although described from material said to be collected by the Japan Marine Fishery Resources Research Center (JAMARC) along the coast of Surinam (Suriname), the coordinates cited in the original description (Okutani, 1982) pinpoint a location that is not the coast of Suriname (near Lat. 6°N, Long. 55°W). Furthermore, the fact that this is one of only two possible species of *Murex* s.s. (and the second is extremely dubious) presently recognized in the western Atlantic, adds to the doubt that these coordinates are correct. Unfortunately, the obvious possibility that the coordinates should read 61° *East* is no solution, as that places the locality in the middle of the Arabian Basin, with water depths of almost 5000 meters. Therefore, I can only say that these coordinates are unlikely, and the true locality is unknown.

Murex surinamensis is undoubtedly a true member of *Murex* sensu stricto, having small, adaperturally directed, spines between the major spines on the siphonal canal. This feature is unique to *Murex* s.s. In addition, the operculum is identical to that found in the group of *Murex pecten* Lightfoot, 1786, with a nucleus that is subcentral rather than terminal, as in most species of *Murex* (see Ponder and Vokes, 1988, text-fig. 1-A). The species most nearly resembles the Australian *Murex queenslandicus* Ponder and Vokes, 1988; however, that species has more numerous spines on the siphonal canal (six in *M. queenslandicus* in contrast to four in *M. surinamensis*).

If it should be proved that *M. surinamensis* is from the western Atlantic, the biogeographical implications are most exciting. There is no known ancestor in this part of the world, but it is obvious that members of many different muricine genera have made their way from one side of the world to the other. We still do not understand much about the mechanisms of these long distance movements. Considering that there are numerous members of *Haustellum,* which I consider to be a western Atlantic group, throughout the Indo-Pacific, there is no compelling reason we should not have species of *Murex* s.s. in the western Atlantic.

MUREX (MUREX) MACULATUS Verrill
Text-figure 1

Murex maculatus VERRILL, 1950, Nautilus, v. 63, no. 4, p. 126, pl. 9, fig. 3 (*non Murex maculatus* Reeve, 1845).

Holotype: Not found; height 47 mm, diameter 19 mm (*fide* Verrill, 1950b, p. 126).

Type locality: Dominica, Lesser Antilles.

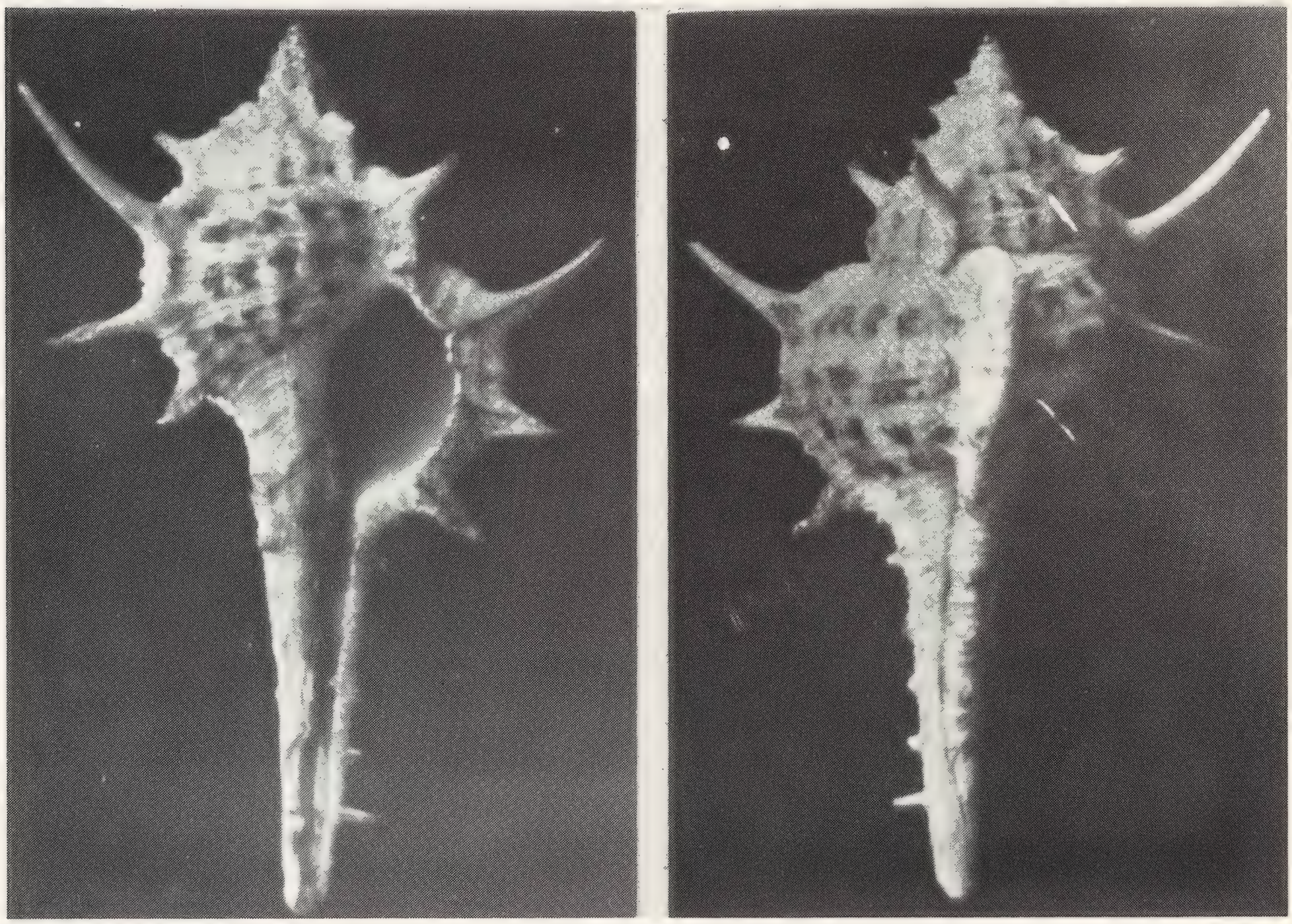
Occurrence: Recent only.

Figured specimen: Holotype (from Verrill's original photographs).

Discussion: Verrill (1950b, p. 126, pl. 9, fig. 3) described *Murex maculatus* from 40-50 fms (73-91 m), off Dominica, Lesser Antilles. His illustration (refigured here as text-fig. 1, from Verrill's original photographs, now in my possession*) shows a shell with just three long straight spines on the varices of the body whorl and five spines on the long straight siphonal canal.

There is a slight similarity to *M. surinamensis,* which may be from the same general area. But the specimens illustrated by Okutani (1982, pl. 1, figs. 1-3) have numerous secondary spines on both

*According to Johnson (1989, p. 12), A. H. Verrill invented the autochrome photographic process in 1902. These prints, which are a strange reddish brown color, are presumed to be made by his process. They have an amazing degree of fine-grained detail, as can be seen from this copy of the originals.



Text-figure 1. *Murex (Murex) maculatus* Verrill (holotype); height 47 mm, diameter 19 mm; Dominica, Lesser Antilles (X 2, approximately).

the body whorl and the canal. The only species that nearly matches the illustration of *M. maculatus* is *M. carbonnieri* (Jousseaume, 1881) (see Ponder and Vokes, 1988, text-fig. 7, holotype) from the Indian Ocean and Red Sea. That species differs in having small secondary spines between the three major spines on the body whorl portion of the varices. Verrill's specimen does not show any trace of these spines. However, the color patterns are suspiciously similar. If one examines the picture of *M. maculatus* closely it is obvious that the color spots have been *painted* on! One assumes that the color of the holotype was faded and Verrill touched up the spots so that they would show better in the photograph. None of Verrill's type material has been found (*fide* Johnson, 1989, p. 16, and personal search). Unless the type ("two living specimens; the type in my collection": Verrill, 1950b, p. 126) or additional material can be located this species will remain an enigma. Should it prove to be valid, then a new name will be necessary, as *M. maculatus* Verrill, 1950, is preoccupied by *M. maculatus* Reeve, 1845.

Genus HAUSTELLUM Schumacher, 1817

Haustellum SCHUMACHER, 1817, Essai Vers Test., p. 213.

Type species: *Murex haustellum* Linné, 1758, by tautonomy.

Discussion: As before, the reader is referred to Ponder and Vokes (1988) for a detailed study of this genus, including the reasons why many of the species customarily placed in *Murex* s.s. have been transferred to *Haustellum*. That study revealed certain morphologic differences, including the presence of a labral tooth in species of *Murex* s.s. but not in *Haustellum*, the presence of rugae* on the parietal lip of species of *Haustellum* but not in *Murex*, early teleoconch ornamentation, color pattern, and other features that convinced me the resemblances between *Murex* s.s. and *Haustellum* are due more to convergence than to close relationship. This was discussed in several later papers (Vokes, 1989b, p.24; 1990a, p. 3; 1990b, p. 124) and need not be repeated here. The ultimate conclusion is that there are no species of *Murex* s.s. (with the possible exception of the two discussed above) in the western Atlantic and those species that formerly were termed "Indo-Pacific" forms of *Murex* s.s. (Vokes, 1963a) should be placed in *Haustellum*.

A brief geologic history of the Muricinae, leading to the development of the genus *Haustellum*, has been given in Ponder and Vokes (1988, p. 13). This was further elaborated in the Dominican Republic study (Vokes, 1989b, p. 25), where I described the evolution of the New World forms of the genus. The group of species that comprise *Haustellum* and *Chicoreus* today began with an Middle Eocene representative of the subgenus *Phyllonotus* [see *C.(P.) initialis*, n. sp., below], which presumably gave rise to the subgenus *Siratus* before the Oligocene. The Early Oligocene *Chicoreus (Siratus) stetopus* (de Gregorio, 1890), which I originally placed in *Phyllonotus*, is the first recognizable species of *Siratus* (see pl. 6, fig. 1; also MacNeil and Dockery, 1984, pl. 4, fig. 16, for a very good example). *Siratus* gave rise to *Chicoreus* s.s. and *Haustellum* sometime before the beginning of the Miocene. If the Pirabas Limestone is in fact correlative with the Tampa Limestone, then *Haustellum messorius* (as *Murex sutilis* White) first appears in the Late Oligocene. It is certainly present by the Late Early Miocene (Baitoa Formation, Dominican Republic). Species of *Chicoreus* s.s. also are present in both the Baitoa and the Chipola formations.

The two lines, *Siratus* and *Haustellum*, continued to develop in parallel fashion throughout the remainder of the geologic record. This fact was demonstrated clearly in the study of the Dominican muricids where there are two distinct species present – *Haustellum messorius* and *Chicoreus (Siratus) domingensis* (Sowerby, 1850) – that are so nearly alike in ornamentation it often is difficult to distinguish them. This problem is discussed in detail in the Dominican work (Vokes, 1989b, p. 25).

*The function of these rugae is unknown; but they appear on almost all species of *Haustellum*, *Siratus*, and *Phyllonotus* (a few species have lost them secondarily). However, they do not appear on any species of *Chicoreus* s.s., indicating to me that this group is less closely related to the others than they are to each other. It is an unfortunate fluke of nomenclatural priority that *Chicoreus* is the oldest taxon.

Inasmuch as *all* of the species considered in Part I are now placed elsewhere, it is useful to list the fossil species with their correct taxonomic placement (see Table 2). In the case of the Recent species originally listed (Vokes, 1963a, Table I) for "Indo-Pacific" form read *Haustellum;* for "Western Atlantic" form read *Chicoreus (Siratus)*. Species no longer in *Haustellum* will be treated systematically with the appropriate genus later in this series.

HAUSTELLUM MESSORIUS (Sowerby)
Plate 1, figures 1-5

Murex messorius Sowerby. BARRIOS M., 1960, Rep. Colombia, Serv. Geol. Nacl., Bol. Geol., v. 6, p. 279, pl. 9, fig. 8.

Murex (Murex) messorius Sowerby. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 103 [not all references], pl. 3, figs. 6, 7 [not fig. 8 = *H. polynematicus* (Brown and Pilsbry)]; VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 197; VOKES, 1967, Tulane Stud. Geol., v. 5, no. 2, p. 81, pl. 1, figs. 1 (lectotype)-3, pl. 2, figs. 1-8.

Murex (Murex) domingensis Sowerby. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, pl. 2, fig. 6 only (not of Sowerby).

[?] *Murex* cf. *messorius* Sowerby. GONZALEZ and FLORES, 1972, Bol. Inst. Oceanogr. Univ. Oriente, v. 11, no. 2, p. 76, text-figs. 2a (radula, as *Thais deltoidea,* not fig. 9a, as stated), 8.

Murex messorius Sowerby. RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 68, pl. 11, fig. 7; FAIR, 1976, The Murex Book, p. 58, pl. 3, fig. 33 only [not figs. 34, 35 = *H. chrysostoma bellus* (Reeve)].

Murex (Haustellum) messorius Sowerby. VOKES, 1989, Bulls. Amer. Paleontology, v. 97, no. 332, p. 25, pl. 1, figs. 1-5.

Synonyms:

Murex nigrescens SOWERBY, 1841, Conch. Illus., pl. 198, fig. 113; SOWERBY, 1841, Zool. Soc. London, Proc., pt. 8 (1840), p. 138; VOKES, 1967, Tulane Stud. Geol., v. 5, no. 2, p. 81.

Murex funiculatus REEVE, 1845, Conch. Icon., v. 3, *Murex,* pl. 19, fig. 74; REEVE, 1846, Zool. Soc. London, Proc., pt. 13 (1845), p. 88 (*non M. funiculatus* Schlotheim, 1820, *nec* Defrance, 1827); VOKES, 1967, Tulane Stud. Geol., v. 5, no. 2, p. 81.

Murex recurvirostris Broderip. GABB, 1873, Amer. Phil. Soc., Trans., (N.S.) v. 15, pt. 1, p. 201; PILBBRY, 1922, Acad. Nat. Sci. Phila., Proc., v. 73, p. 353; WOODRING *in* DURHAM, ARGELLANO, and PECK, 1955, Geol. Soc. Amer., Bull., v. 66, p. 984; WOODRING, 1959, U.S. Geol. Surv., Prof. Paper 306-B, p. 214, pl. 35, figs. 5, 8, pl. 36, figs. 11, 12 (not of Broderip).

Murex sutilis WHITE, 1887, Mus. Nacl. Rio de Janiero, Arch., v. 7, p. 137, pl. 11, fig. 11; VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 103, pl. 4, fig. 8.

Murex (Murex) woodringi CLENCH and PÉREZ FARFANTE, 1945, Johnsonia, v. 1, no. 17, p. 9, pl. 4, figs. 1-3; VOKES, 1965,

TABLE 2. Fossil species originally covered in Part I.

SPECIES NAME	CURRENT PLACEMENT
M. quirosensis F. Hodson	*Siratus*
M. chipolanus Dall	*Siratus*
M. gardnerae Vokes = *juliagardnerae* Vokes	*Siratus*
M. gilli (Maury)	*Haustellum*
M. polynematicus Brown and Pilsbry	*Haustellum*
M. vaughani Maury	*Dermomurex (Takia)*
M. pennai Maury = *pennae* Maury	*Haustellum*
M. toria Maury = *yaquensis* Maury	*Siratus*
M. williamsi Maury	*Cymatium (Gutturnium)*
M. sutilis White = *messorius* Sowerby	*Haustellum*
M. messorius Sowerby	*Haustellum*
M. nicholsi Gardner	*Siratus*
M. domingensis Sowerby	*Siratus*
M. yaquensis Maury	*Siratus*
M. antillarum Hinds = *formosus* Sowerby	*Siratus*
M. rubidus Baker	*Haustellum*
M. chrysostoma Sowerby	*Haustellum*
M. anniae Smith	*Haustellum*
M. anniae bellegladeensis Vokes	*Haustellum*

Tulane Stud. Geol., v. 3, no. 4, p. 197; VOKES, 1967, Tulane Stud. Geol., v. 5, no. 2, p. 81.

Murex messorius var. *gustaviensis* NOWELL-USTICKE, 1969, Suppl. List. New Shells, p. 15, pl. 3, fig. 649.

Murex garciai PETUCH, 1987, New Caribbean Moll. Faunas, p. 66, pl. 11, figs. 9, 10.

Murex samui PETUCH, 1987, New Caribbean Moll. Faunas, p. 67, pl. 11, figs. 7, 8.

The following references, included under *M. messorius* in 1963, p. 103, *do not* apply to this species:

Murex recurvirostris Broderip. RUTSCH, 1934, Schweizer. Palaeont. Gesell., Abh., v. 54, no. 3, p. 64, pl. 4, fig. 1; v. 55, no. 1, p. 136 [= *H. donmoorei* (Bullis)].

Murex (Murex) recurvirostris Broderip. PERRILLIAT MONTOYA, 1960, Paleontología Mexicana, no. 8, p. 21, pl. 3, figs. 9, 10 [= *H. bellegladeensis* (Vokes)].

Murex (Murex) recurvirostris recurvirostris Broderip. WEISBORD, 1962, Bulls. Amer. Paleontology, v. 42, no. 193, p. 278, pl. 26, figs. 3, 4 [= *H. donmoorei* (Bullis)].

Lectotype: Brit. Mus. (Nat. Hist.), BMNH 1964-349 (designated by Vokes, 1967a, p. 82); height 64 mm, diameter 29 mm.

Type locality: St. Lucia, Windward Islands, Lesser Antilles (designated by Vokes, 1967a, p. 82).

Occurrence: Pirabas Limestone, Brazil; Thomonde Formation, Haiti; Encanto Formation, Veracruz, Mexico; Quebradillas Limestone, Puerto Rico; Upper Tubará Group, Colombia; Gatun Formation, Panama; Río Banano Formation, Costa Rica; Baitoa, Las Cahobas, Cercado, Gurabo, and Mao formations, Dominican Republic; Cumaná Formation, Venezuela; Bowden Formation, Jamaica; unnamed Pleistocene formation, Barbados. Recent, western Atlantic from Greater Antilles to Venezuela.

Figured specimens: Fig. 1, USNM 878001; height 41.3 mm, diameter 20.9 mm; Guadeloupe, F. W. I. Fig. 2, Mus. Nacl. Rio de Janiero 2953-1 (holotype – *Murex sutilis* White); height 38 mm, diameter 17 mm (*fide* White, 1887, p. 138; *ex*

PLATE 1

Figures — Page

1-5. *Haustellum messorius* (Sowerby) 9
1. (X 1 1/2) USNM 878001; height 41.3 mm, diameter 20.9 mm.
Locality: Guadeloupe, F. W. I; Recent.
2. (X 1 1/2) Mus. Nacl. Rio de Janiero 2953-1 (holotype – *Murex sutilis* White); height 38 mm, diameter 17 mm (*fide* White, 1887, p. 138; *ex* White, 1887, pl. 11, fig. 11).
3. (X 1) USNM 878002; height 46.7 mm, diameter 32 mm.
Locality: TU R-109, Panama; sub-Recent.
4. (X 1 1/2) USNM 323852; height 36.6 mm, diameter 21.6 mm.
Locality: TU 1215, Dominican Republic; Gurabo Formation.
5. (X 1 1/2) UCMP 38644; height 26.5 mm, diameter 15 mm.
Locality: UCMP S-64, Bolívar, Colombia; Tubará Group.

7-8. *Haustellum gilli* (Maury) 12
7. (X 1 1/2) USNM 450345; height 34.6 mm, diameter 21.4 mm.
Locality: TU 951, Florida; Chipola Formation.
8. (X 1 1/4) UCMP 38645; height 39.8 mm, diameter (including spines) 28.4 mm.
Locality: UCMP S-8360, Paraguaná Peninsula, Venezuela; Cantaure Formation.

6, 9, 10. *Haustellum chrysostoma* (Sowerby) (X 1) 13
6. BMNH 1974-90 (syntype – *M. bellus* Reeve); height 53.4 mm, diameter 27 mm.
Locality: Unknown; Recent.
9. USNM 643760, height 47 mm, diameter 29 mm.
Locality: USGS 18253, Cabo Blanco, Venezuela; Mare Formation.
10. UCMP 38646; height 50.9 mm, diameter 36 mm.
Locality: UCMP S-110, Cumaná, Venezuela; Cumaná Formation.

11. *Haustellum polynematicus* (Brown and Pilsbry) (X 1 1/2) 13
USNM 450346; height 36.8 mm, diameter 23.4 mm.
Locality: TU 958, Panama; Gatun Formation.
(Color pattern under ultraviolet light)

12. *Haustellum rubidus* (Baker) (X 1 1/2) 17
USNM 878003; height 30.5 mm, diameter 16.4 mm.
Locality: TU R-42, off Florida; Recent.

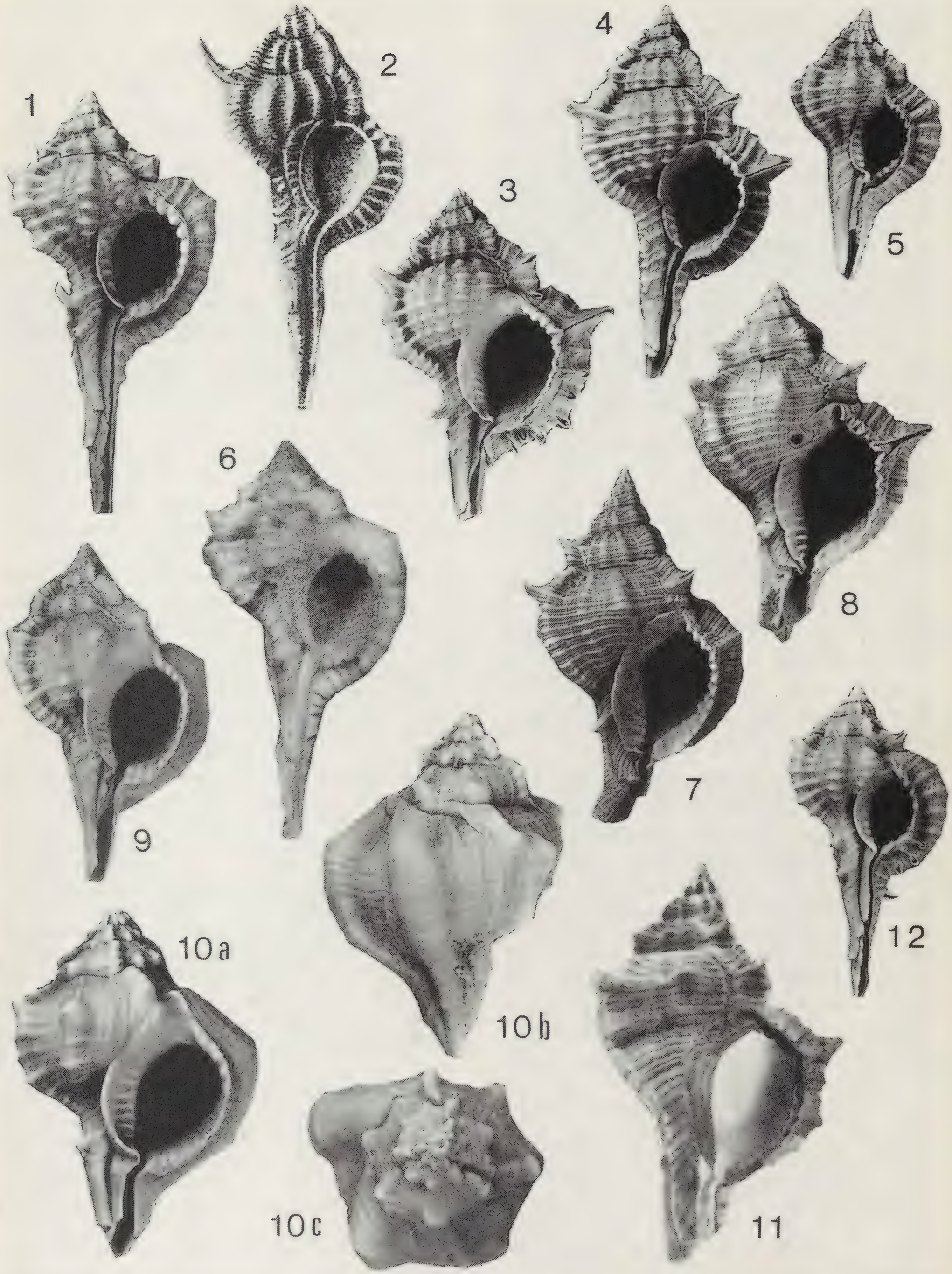


PLATE 1

White, 1887, pl. 11, fig. 11). Fig. 3, USNM 878002; height 46.7 mm, diameter 32 mm; locality TU R-109. Fig. 4, USNM 323852; height 36.6 mm, diameter 21.6 mm; locality TU 1215. Fig. 5, UCMP 38644; height 26.5 mm, diameter 15 mm; locality UCMP S-64, Depto. de Bolívar, Colombia. Additional localities: TU 589, 635, 705, 757, 958, 967, 1241. For localities in the Dominican Republic, see Vokes, 1989b, p. 27.

Discussion: The species *H. messorius* is among the most widespread and abundant in the western Atlantic. It is the oldest known species of *Haustellum,* first occurring in the Pirabas Limestone, and continuing throughout the geologic record up to the present. It is especially common in all of the more shallow-water Neogene formations of the Dominican Republic and has been discussed extensively in the report on that country (Vokes, 1989b, p. 25). In addition to the citations given in the synonymy above, there are a number of other references to occurrences in the Dominican Republic given in that publication. These are all unillustrated lists of fossil occurrences and are not repeated here.

In the Recent fauna the species is widespread throughout the region south of Florida and north of Brazil. There have been a number of names proposed for what I consider infraspecific variations, all of which have been figured, some in color, in a popular work (Vokes, 1990a) on the subject.

Gonzalez and Flores (1972, p. 76, text-fig. 8) have illustrated six specimens of what they call "*Murex* cf. *messorius,*" from the coast of Venezuela. Their uncertainty is understandable, as the specimens are certainly atypical with low spires and almost square whorls, as a result of a strong spiral cord at the base of the body whorl. Given the species variability of *H. messorius,* they are probably just that – atypical specimens – but they may prove to be a new species.

Haustellum pennae (Maury)
Plate 2, figure 4

Murex domingensis Sowerby. MAURY, 1917, Bulls. Amer. Paleontology, v. 5, no. 29, p. 102(266) [in part, "the mutation with four or five intervarical ribs" only], pl. 16(42), fig. 5.

Murex pennae MAURY, 1925, Ser. Geol. Min. Brazil, Mon. 4, p. 141, pl. 6, fig. 4.

Murex (Murex) pennai Maury [emend.]. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 102, pl. 4, fig. 5 (*ex* Maury, 1925, pl. 6, fig. 4).

Murex (Murex) domingensis Sowerby. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, pl. 2, fig. 7 only (not of Sowerby).

Murex (Haustellum) pennae Maury. VOKES, 1989, Bulls. Amer. Paleontology, v. 97, no. 332, p. 27, pl. 1, figs. 9-13.

Holotype: Not found; height 50 mm, diameter 20 mm (*fide* Maury, 1925).

Type locality: Pirabas Limestone; mouth of Rio Pirabas, State of Pará, Brazil.

Occurrence: Pirabas Limestone, Brazil; Cercado and Gurabo formations, Dominican Republic.

Figured specimen: USNM 323854; height 48 mm, diameter 23.1 mm; locality TU 1219. For additional localities in the Dominican Republic, see Vokes, 1989b, p. 30.

Discussion: This is one of the more common species in the Cercado Formation and shallow-water portions of the Gurabo Formation in the Dominican Republic. It has been discussed extensively in the Dominican Republic report (Vokes, 1989b, p. 27) and little needs to be added here. As noted in that discussion, *H. pennae* is much more similar to the Recent Indo-Pacific species *H. mindanaoensis* (Sowerby, 1841) than it is to any western Atlantic form, fossil or Recent. The relationships certainly are not understood.

Haustellum gilli (Maury)
Plate 1, figures 7, 8

Murex (Murex) gilli Maury. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 100, pl. 2, figs. 1-4.

Chicoreus (Siratus) gilli (Maury). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 183; VOKES, 1972, Earth Sci., v. 25, no. 3, p. 122, pl. 1, fig. 5.

Murex (Murex) polynematicus Brown and Pilsbry. JUNG, 1965, Bulls. Amer. Paleontology, v. 49, no. 223, p. 520, pl. 69, fig. 6 (not of Brown and Pilsbry).

Murex (Haustellum) gilli (Maury). VOKES, 1988, Tulane Stud. Geol. Paleont., v. 21, no. 1, p. 17.

Holotype: USNM 639075; height 9 mm, diameter 4 mm.

Type locality: Oak Grove Sand; Oak Grove, Florida (= TU 91).

Occurrence: Oak Grove Sand and Chipola Formation, Florida; Cantaure Formation, Venezuela.

Figured specimens: Fig. 7, USNM 450345; height 34.6 mm, diameter 21.4 mm; locality TU 951. Fig. 8, UCMP 38645; height 39.8 mm, diameter (including spines) 28.4 mm; locality UCMP

S-8360, Paraguaná Peninsula, Venezuela. Additional localities: TU 457, 554, 555, 655, 709, 711, 787, 818, 820, 823, 825, 827, 830, 831, 998, 999, 1051, 1269.

Discussion: As noted in a previous paper (Vokes, 1988, p. 17), specimens from the Early Miocene Cantaure Formation of Venezuela, cited as *M. polynematicus* by Jung (1965, p. 520, pl. 69, fig. 6) are better referred to the correlative *H. gilli,* although there is a certain resemblance to the younger Panamanian *H. polynematicus.* We have several specimens from the Cantaure Formation (TU 1269) and they lack the lower spire, smaller aperture and, especially, the second varical spine, characters that distinguish *H. polynematicus* from *H. gilli* (compare pl. 1, figs. 7, 8, and 11).

HAUSTELLUM POLYNEMATICUS (Brown and Pilsbry) Plate 1, figure 11

Murex (Murex) gilli polynematicus Brown and Pilsbry. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 101, pl. 2, fig. 5.

Murex messorius Sowerby. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, pl. 3, fig. 8 only (not of Sowerby).

Murex (Murex) polynematicus Brown and Pilsbry. OLSSON, 1964, Neogene Moll. Northwest. Ecuador, p. 137, pl. 29, figs. 2, 2a.

Chicoreus (Siratus) gilli polynematicus (Brown and Pilsbry). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 183.

Not *Murex (Murex) polynematicus* Brown and Pilsbry. JUNG, 1965, Bulls. Amer. Paleontology, v. 49, no. 223, p. 520, pl. 69, fig. 6 [= *H. gilli* (Maury)].

Murex (Haustellum) polynematicus Brown and Pilsbry. VOKES, 1988, Tulane Stud. Geol. Paleont., v. 21, no. 1, p. 17, pl. 1, fig. 6.

Haustellum polynematicus (Brown and Pilsbry). VOKES, 1989, Tulane Stud. Geol. Paleont., v. 22, no. 4, p. 112, pl. 1, fig. 2.

Holotype: Acad. Nat. Sci. Philadelphia, ANSP 1719; height 54.5 mm, diameter 33.7 mm.

Type locality: Gatun Formation; Gatun Locks, Panama.

Occurrence: Angostura Formation and Esmeraldas Beds, Ecuador; Gatun Formation, Panama; (?)Angostura Formation, Nariño, Colombia.

Figured specimen: USNM 450346; height 36.8 mm, diameter 23.4 mm; locality TU 958. Additional localities: TU 757, 959, 961, 1398, 1431, 1432, 1433, 1507.

Discussion: Haustellum gilli and *H. polynematicus* have been a problem with regard to their proper generic placement. With a better understanding of the relationship between *Murex* s.s. and *Haustellum* this problem is finally resolved (to my satisfaction, at least), for among the muricids of the region, these two, plus their close relative *H. chrysostoma* (Sowerby) [see below], are the most similar to typical Indo-Pacific species of *Haustellum.*

This species has been discussed in two other papers (Vokes, 1988, p. 18; 1989c, p. 112) dealing with the Mio-Pliocene of the Pacific coast of Ecuador where the species occurs, as well as in southern Colombia. But the form is most common in the Gatun Formation, from whence it was originally described. In the Tulane Collections there are over 300 specimens from seven Gatun localities.

As noted elsewhere (Vokes, 1989b, p. 24, etc.), the presence of wide brown spiral bands is characteristic of most species of *Haustellum.* Although the line of *H. gilli*-*H. polynematicus* is now extinct and there are no living descendants, examination of *H. polynematicus* under ultraviolet light reveals that it (and presumably *H. gilli* also) had the typical color pattern (see pl. 1, fig. 11).

HAUSTELLUM CHRYSOSTOMA (Sowerby) Plate 1, figures 6, 9, 10

Murex (Murex) chrysostomus [*sic*] Sowerby. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 109, pl. 4, fig. 9.

Murex (Murex) chrysostoma Sowerby. JUNG, 1969, Bulls. Amer. Paleontology, v. 55, no. 247, p. 489, pl. 49, figs. 8-10.

Not *Murex chrysostoma* Sowerby var.? RIOS, 1970, Coastal Brazilian Seashells, p. 77, pl. 21; RIOS, 1975, Brazilian Marine Moll. Icon., p. 84, pl. 24, fig. 339 [= *Chicoreus (Siratus) carolynae* Vokes].

Murex chrysostomus [*sic*] Sowerby. GONZALEZ and FLORES, 1972, Bol. Inst. Oceanogr. Univ. Oriente, v. 11, no. 2, p. 79, text-figs. 2c (radula, as *Thais haemastoma floridana,* not fig. 9c, as stated), 11.

Not *Murex chrysostoma* Sowerby. RIOS, 1985, Seashells of Brazil, p. 81, pl. 29, fig. 354 [= *Chicoreus (Siratus) carolynae* Vokes].

Murex chrysostoma Sowerby. RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 64, pl. 10, figs. 10, 11; FAIR, 1976, The Murex Book, p. 30, pl. 3, fig. 18 (?syntype).

Murex messorius Sowerby. PETUCH, 1988, Neogene History Trop. Amer. Moll., p. 157,

pl. 37, fig. 13 (not of Sowerby).

Haustellum chrysostoma (Sowerby). VOKES, 1989, Tulane Stud. Geol. Paleont., v. 22, no. 4, p. 123, pl. 1, figs. 1-3.

? Synonym:

Murex bellus REEVE, 1845, Conch. Icon., v. 3, *Murex*, pl. 21, fig. 84; REEVE, 1846, Zool. Soc. London, Proc., pt. 13 (1846), p. 88.

Murex bellus Reeve (= *Murex chrysostoma*). CLENCH and PÉREZ FARFANTE, 1945, Johnsonia, v. 1,no. 17, p. 10; RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 64, pl. 10, fig. 11.

Murex messorius Sowerby. FAIR, 1976, The Murex Book, pl. 3, figs. 34, 35 onlv.

Holotype: Not found; height 71 mm, diameter 38.2 mm (measurements of specimen figured by Sowerby, 1834, pl. 58, fig. 1).

Type locality: Tobago Island, Trinidad and Tobago (designated by Clench and Pérez Farfante, 1945, p. 12).

Occurrence: Bahía Formation, Ecuador; Melajo Clay, Trinidad; Mare and Cumaná formations, Venezuela. Recent, northern South America, from Goajira Peninsula, Colombia, to Trinidad and Tobago (Vokes, 1989d, p. 126).

Figured specimens: Fig. 6, BMNH 1974-90 (syntype – *M. bellus* Reeve); height 53.4 mm, diameter 27 mm; locality unknown. Fig. 9, USNM 643760, height 47 mm, diameter 29 mm; locality USGS 18253, Cabo Blanco area, Venezuela. Fig. 10, UCMP 38646; height 50.9 mm, diameter 36.0 mm; locality UCMP S-110, Cumaná, Edo. de Sucre, Venezuela.

Discussion: In a recent paper (Vokes, 1989d), this species was reported from the Early Pliocene Bahia Formation of the Pacific coast of Ecuador. In view of the fact that today *H. chrysostoma* is limited to northern South America, this is a considerable range extension. It is not, however, an extension of age, as Jung (1969, p. 489, pl. 49, figs. 8-10) has reported the species from the Late Miocene Melajo Clay of Trinidad.

In the same paper its resemblance to the Miocene to Recent species *H. messorius* (Sowerby) was examined in detail and it was concluded that *H. chrysostoma* is generally larger, smoother, has a more appressed suture, a more inflated body whorl and a larger aperture, with a more expanded parietal shield that is at least partially yellow in color.

PLATE 2

Figures — Page

1, 2. *Haustellum mimiwilsoni* Vokes, n. sp. 16
1. (X 1) UCMP 14142 (holotype); height 60 mm, diameter 39.7mm.
Locality: UCMP S-122, Isla Cubagua, Venezuela; Cumaná Formation.
2. USNM 323864 (paratype); height (incomplete) 13.4 mm, diameter 13.5 mm (fig. 2a, X 3; fig. 2b, X 10).
Locality: TU 589, Costa Rica; Río Banano Formation.

3. ?*Haustellum adelosus* (Vokes) (X 1 1/2) 17
NMB H 17000 (holotype); height 42.7 mm, diameter 24.4 mm.
Locality: NMB 16818, Cañada de Zamba, Dominican Republic (= TU 1354); Gurabo Formation.

4. *Haustellum pennae* (Maury) (X 1 1/2) 12
USNM 323854; height 48 mm, diameter 23.1 mm.
Locality: TU 1219, Dominican Republic; Gurabo Formation.

5, 6. *Haustellum olssoni* (Vokes) 20
5. (X 1 1/2) USNM 450347; height 38.5 mm, diameter (including spines) 23.8 mm.
Locality: TU 954, Costa Rica; Moín Formation.
6. (X 10) USNM 878004; height 17.6 mm, diameter (excluding spines) 7.6 mm.
Locality: TU R-101, off Panama; Recent.

7-9. *Haustellum donmoorei* (Bullis) 18
7. (X 1 1/4) USNM 878005; height 50.8 mm, diameter 26 mm.
Locality: off Guyana; Recent.
8. (X 10) Vokes Coll. (paratype); height 34.2 mm, diameter (including spines) 16.3 mm.
Locality: *Oregon* Sta. 2275, off Suriname; Recent.
9. (X 1) PRI 26200 (paratype – *M. olssoni* Vokes); height (incomplete) 50 mm, diameter 33 mm.
Locality: Cabo Blanco, Venezuela; Mare Formation.

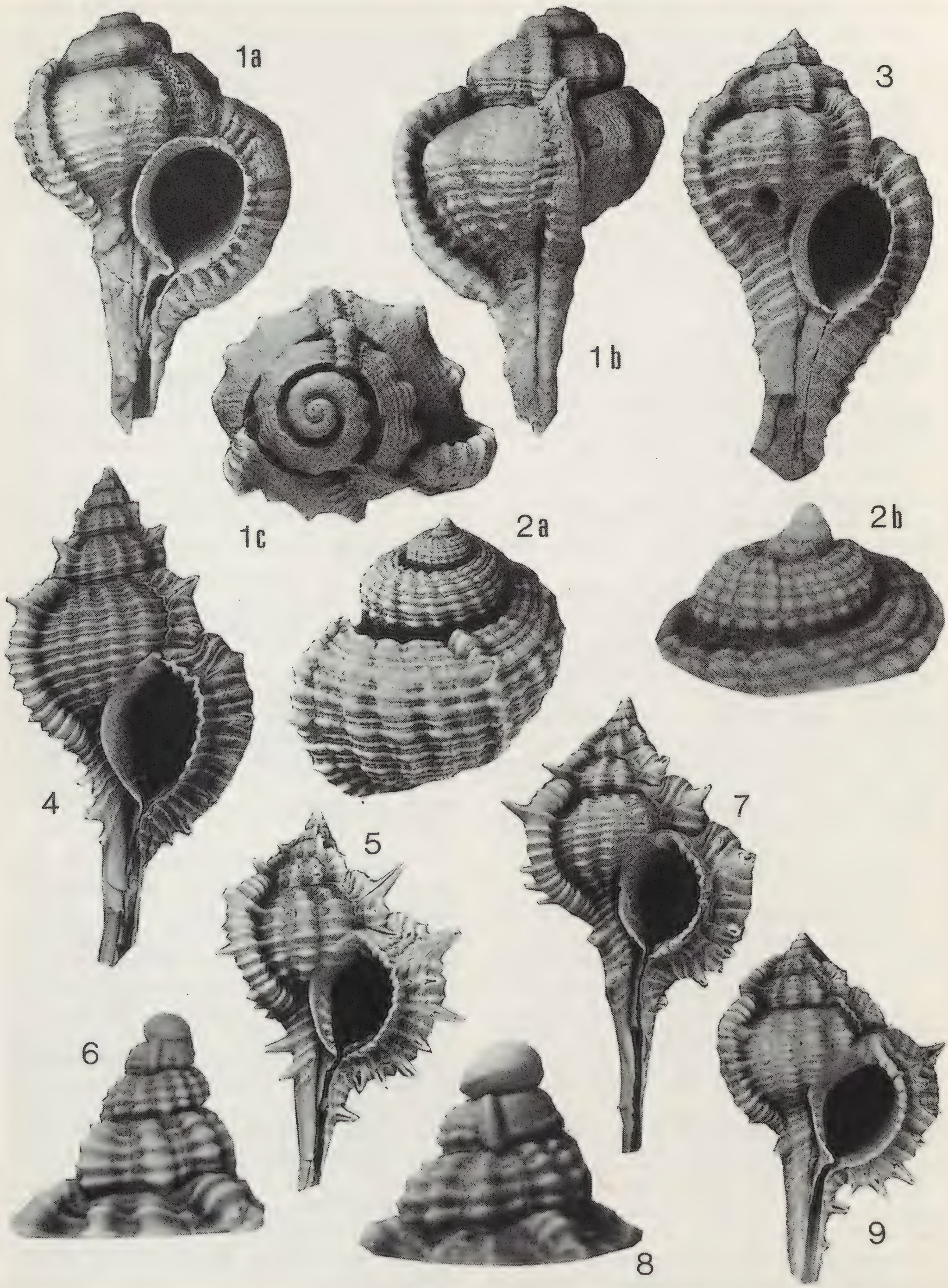


PLATE 2

The species *Murex bellus* Reeve has been considered by most writers to be a synonym of *H. chrysostoma*. Examination of the type lot in the British Museum (Natural History) shows that there are certain differences. The shell is generally smaller, with a less inflated body whorl. Examples that match the lectotype (BMNH 1974-90; see pl. 1, fig. 6 herein) best (*e.g.*, Radwin and D'Attilio, 1976, pl. 10, fig. 11; de Jong and Coomans, 1988, pl. 36, fig. 389B) come from Aruba or Curaçao. According to de Jong and Coomans (1988, p. 71), both forms live within 12 km of each other, but the specimens that match *H. bellus* live under sand, and those that match *H. chrysostoma* (de Jong and Coomans, 1988, pl. 36, fig. 389A) live on a muddy substrate. Therefore, the *H. bellus* type is probably just an ecophenotypic variation.

Petuch (1976) has described the ecology of a community that includes *H. chrysostoma,* along the coast of Venezuela. He notes that the species feeds on *Chione, Tellina,* and *Macoma.*

In the collections of the Museum of Paleontology, University of California, Berkeley, there are several specimens of *H. chrysostoma* from the type locality of the Cumaná Formation at Cumaná, Edo. de Sucre, Venezuela. At one of the localities (S-110, 2.5 km northeast of the "Castillo") there are several examples that are either gerontic or some sort of ecologic variants. They begin as normal shells with three varices but on the last whorl develop an extra varix (see pl. 1, fig. 10).

HAUSTELLUM MIMIWILSONI Vokes, n. sp.
Plate 2, figures 1, 2

Murex (Haustellum) sp. VOKES, 1974, Malac. Soc. Australia, Jour., v. 3, no. 1, p. 13, pl. 3, fig. 2.

Murex (?Haustellum) species aff. *M. wilsoni* (D'Attilio and Old). VOKES, 1989, Bulls. Amer. Paleontology, v. 97, no. 332, p. 30, pl. 1, fig. 8.

Description: Shell consisting of probably four teleoconch whorls and a protoconch of three and one-half smooth, slightly bulbous whorls, ending at a small varix. Spiral ornamentation on earliest teleoconch whorls of several alternating wide and narrow flattened cords, gradually increasing in number to approximately 10 major cords on the body whorl, plus an additional two major cords on siphonal canal. Axial ornamentation on earliest teleoconch whorls of faint ridges, giving an undulatory appearance to the spiral cords; about 24 ridges per whorl until on fourth post-nuclear whorl three of these ridges strengthen into varices, with others remaining as three elongate swellings between each pair of varices. On body whorl the portion of these ridges at the shoulder more produced, forming pointed nodes. Varices rounded, ornamented only by the spiral cords passing over, greatly excavated abaperturally. Whorls inflated, suture with a deep channel, sharply edged by the posteriormost spiral cord, crossed only by adapical portion of varices. Aperture circular, almost entire; inner lip appressed at posterior end, free standing and expanded at anterior end, marked by numerous elongate rugae over entire length. Inside of outer lip with faint elongate lirations, approximately corresponding to spaces between major cords. Siphonal canal long, straight, almost closed over but open by a narrow slit.

Holotype: Museum of Paleontology, University of California, Berkeley, UCMP 14142; height 60 mm, diameter 39.7 mm. Collected by P. Andrews, C. T. Newcomb, and L. W. Henry, March 9, 1930.

Type locality: UCMP S-122, Cumaná Formation; about 400 m south of house at Las Calderas, Isla Cubagua, Edo. de Nueva Esparta, Venezuela.

Etymology of name: *mimus* (L.) = mimic + *wilsoni,* an Australian species.

Occurrence: Cumaná Formation, Venezuela; Río Banano Formation, Costa Rica.

Figured specimens: Fig. 1, UCMP 14142 (holotype). Fig. 2, USNM 323864 (paratype); height (incomplete) 13.4 mm, diameter 13.5 mm; locality TU 589.

Discussion: In the collections of the Museum of Paleontology, University of California, Berkeley, there is a single specimen of a most unusual species of *Haustellum.* I originally considered this species an American "ancestor" of the Recent Australian *H. wilsoni* D'Attilio and Old, 1971 (Vokes, 1974b, p. 13). At that time there was just this unique example, but subsequent collecting has provided a second incomplete specimen, which is placed in the same species. Unfortunately the early whorls of the Venezuelan shell are completely eroded, and the later whorls of the Costa Rican shell are lacking, so this is not absolutely certain. The two are so totally different from all other American species that the two specimens are believed to be the same species.

The similarity to *H. wilsoni* is striking. One difference is the nature of the protoconch, which in *H. wilsoni* is extremely large (2.5 mm in diameter in contrast to 1.0 mm in the new species), and another is the lack of rugae on the inner lip of the Australian species. The two shells are figured for comparison in the aforementioned paper (Vokes, 1974b, pl. 3, figs. 1 and 2).

The only American species that has even a slight resemblance is the Dominican ?*H. adelosus* (Vokes, 1989), discussed below. This species has a similar-sized protoconch but with only two whorls in contrast to the three and one-half whorls in *H. mimiwilsoni;* the siphonal canal is wider, with a small varical flange along its length; and the suture is not channeled. However, this species is the only apparently related form outside of Australia.

?Haustellum adelosus (Vokes)
Plate 2, figure 3

Murex (?Haustellum) adelosus VOKES, 1989, Bulls. Amer. Paleontology, v. 97, no. 332, p. 30, pl. 1, figs. 6, 7.

Holotype: Naturhistorisches Museum Basel, NMB H 17000; height 42.7 mm, diameter 24.4 mm.

Type locality: Gurabo Formation; Cañada de Zamba, west side of Río Cana, approximately 4.5 km (airline) below the ford at Caimito, Dominican Republic (= TU 1354).

Occurrence: Cercado and Gurabo formations, Dominican Republic.

Figured specimen: NMB H 17000 (holotype). For additional localities in the Dominican Republic, see Vokes, 1989b, p. 31.

Discussion: This unusual species, known only from the Dominican Republic, does not resemble any other species of muricid, except *H. mimiwilsoni,* as noted above. Furthermore, *H. adelosus* is unique in possessing an expanded varical flange along the siphonal canal, which makes its assignment to the genus *Haustellum* questionable. But, as there is no other genus to which it bears a closer relationship, and given the apparent close relationship with *H. mimiwilsoni,* it will be placed here provisionally.

All of the localities at which this species is found are coral reefs, and it is presumed that this species was a reef-dweller. It is regretable that there is no living descendant to which we may compare ?*H. adelosus* for verification of this ecological information.

Haustellum rubidus (F. C. Baker)
Plate 1, figure 12

Murex (Murex) rubidus Baker. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 108, pl. 4, figs. 3, 4.

Murex rubidus Baker. RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 71, pl. 11, fig. 15; FAIR, 1976, The Murex Book, p. 73, pl. 3, fig. 40.

Synonyns:

Murex cracherodi SOWERBY, 1879, Thes. Conch., v. 4, *Murex,* p. 5 [nude name; label in BMNH on specimen of *H. rubidus*].

Murex marcoensis SOWERBY, 1900, Jour. of Malacology, v. 7, p. 162 (figured, with name spelled *narcoensis* in error).

Murex recurvirostris delicatus M. SMITH, 1940, Nautilus, v. 54, p. 45.

Murex citrinus M. SMITH, 1940, Nautilus, v. 54, p. 45; CLENCH and PÉREZ FARFANTE, 1945, Johnsonia, v. 1, no. 17, p. 8, pl. 3, fig. 6 (holotype).

Lectotype (designated by Clench and Pérez Farfante, 1945, p. 8): Harvard Mus. Comp. Zool., MCZ 147272; height 37.4 mm, diameter 21.5 mm (as figured by Clench and Pérez Farfante, 1945, pl. 3, fig. 2)

Type locality: Cedar Keys, Florida.

Occurrence: Pinecrest, Caloosahatchee, and Bermont formations, Florida; Moín Formation, Costa Rica. Recent, North Carolina to northern South America.

Figured specimen: USNM 878003; height 30.5 mm, diameter 16.4 mm; locality TU R-42. Additional localities: TU 536, 579, 580, 583, 725–27, 729, 733, 743, 747, 755, 759, 767–70, 788, 792, 802, 803, 939, 954, 973, 975, 978, 991, 1000, 1023, 1174, 1175, 1177, 1240, 1491, 1512, 1524.

Discussion: Haustellum rubidus is common in the Plio-Pleistocene beds of southern Florida. However, there are also rare specimens from the Moín Formation, Costa Rica (TU 954, 1240). The more southern specimens differ slightly from the typical form in that they have a more appressed suture but otherwise the shells are indistinguishable. In the Recent fauna the species occurs, for the most part, from North Carolina to the east and west coasts of Florida and the Bahama Islands. But it also occurs off northern Honduras (Bay Islands, Kevan Sunderland Collection), northern South America (to Ceará, Brazil: Rios, 1985, p. 82) and very fine specimens are being dredged off the Atlantic coast of Panama in about 36 meters.

The species is extremely close to *H. messorius* and may be distinguished princi-

pally by its smaller size. This causes difficulty with young examples of *H. messorius,* but at equal height, *H. messorius* has one less whorl than *H. rubidus.* The protoconchs are also slightly different; that of *H. messorius* has one and one-half whorls but *H. rubidus* has about one and three-quarters whorls (*not* two and one-half, as stated in Radwin and D'Attilio, 1976, p. 71). The intervarical nodes are larger in *H. rubidus* and the spiral ornamentation less pronounced, giving the shell a "smoother" aspect than the more nodulose *H. messorius.*

HAUSTELLUM DONMOOREI (Bullis)
Plate 2, figures 7-9

Murex recurvirostris Broderip. RUTSCH, 1934, Schweizer. Palaeont. Gesell., Abh., v. 54, no. 3, p. 64, pl. 4, fig. 1; v. 55, no. 1, p. 136 (not of Broderip).

Murex (Murex) recurvirostris recurvirostris Broderip. WEISBORD, 1962, Bulls. Amer. Paleontology, v. 42, no. 193, p. 278, pl. 26, figs. 3, 4 (not of Broderip).

Murex (Murex) donmoorei BULLIS, 1964, Tulane Stud. Zoology, v. 11, no. 4, p. 101, figs. 1, 2; BAYER, 1971, Bull. Mar. Sci., v. 21, no. 1, p. 152, fig. 25 (two specimens).

Murex (Murex) olssoni VOKES, 1967, Tulane Stud. Geol., v. 5, no. 2, p. 84 [in part, Cabo Blanco paratype only], pl. 3, fig. 3 only.

Murex donmoorei Bullis. GONZALEZ and FLORES, 1972, Bol. Inst. Oceanogr. Univ. Oriente, v. 11, no. 2, p. 78, text-figs. 2b (radula, as *Thais rustica,* not fig. 9b, as stated), 10; RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 65, pl. 10, fig. 3, text-fig. 36 (protoconch); FAIR, 1976, The Murex Book, p. 38, pl. 3, fig. 38 (holotype); PETUCH, 1987, p. 88, pl. 18, fig. 5 (same specimen as Bayer's upper figure).

Holotype: USNM 635146; height 50 mm, diameter (excluding spines) 22.5 mm.

PLATE 3

Figures Page

1-3. *Haustellum anniae* (Smith) (X 1 1/2) 21
1. USNM 608528; height 36 mm, diameter (excluding spines) 16 mm.
Locality: off Yucatán Peninsula; Recent.
2. USNM 878006; height 32.3 mm, diameter (excluding spines) 13 mm (fig. 2b, X 10).
Locality: TU R-42, off Florida; Recent.
3. USNM 450348; height 37.5 mm, diameter (excluding spines) 16.3 mm (fig. 3b, X 10).
Locality: TU 759, Florida; Bermont Formation.

4-8. *Haustellum bellegladeensis* (Vokes) (X 1 1/2) 21
4. USNM 450349; height 38.3 mm, diameter 19.3 mm.
Locality: TU 539B, Florida; Caloosahatchee Formation.
5. USNM 450350; height 41.5 mm, diameter 22.5 mm.
Locality: TU 727, Florida; Bermont Formation.
6. (X 10) USNM 450351; height 27.9 mm, diameter (excluding spines) 16 mm.
Locality: TU 201, Florida; Bermont Formation.
7. USNM 878007; height 37.4 mm, diameter 20.5 mm.
Locality: TU R-42, off Florida; Recent.
8. USNM 450352; height 31.4 mm, diameter 21 mm.
Locality: TU 1046, Mexico; Agueguexquite Formation.

9. *Haustellum sallasi* (Rehder and Abbott) (X 1 1/2) 22
USNM 878008; height 36.4 mm, diameter 21 mm.
Locality: off Cabo Catoche, Quintana Roo, Mexico; Recent.

10-12. *Haustellum cabritii* (Bernardi) 23
10. (X 1 1/2) USNM 450353; height (as is) 30.5 mm.
Locality: TU 953, Costa Rica; Moín Formation.
11. (fig. 11a, X 2; fig. 11b, X 10) USNM 450354; height (incomplete) 18.5 mm, diameter (excluding spines) 11 mm.
Locality: TU 954, Costa Rica; Moín Formation.
12. (X 2) USNM 450355; height (as is) 36.4 mm.
Locality: TU 954, Costa Rica; Moín Formation.

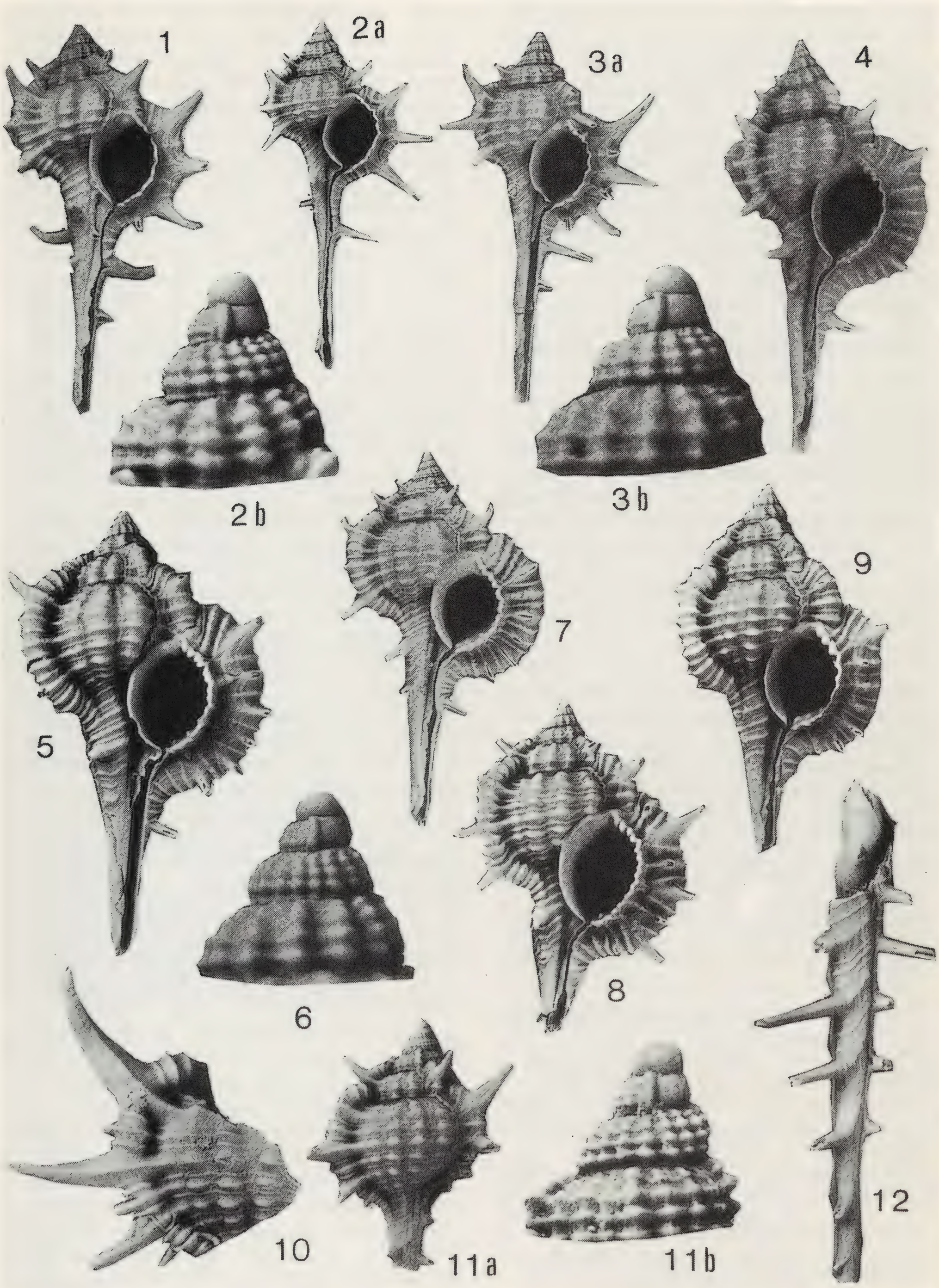


PLATE 3

Type locality: *Oregon* Station 2254, 45 mi north of St. Andrews Point, British Guiana (Guyana), 20-22 fms (37-40 m).

Occurrence: Punta Gavilan and Mare formations, Venezuela. Recent, northern South America, from French Guiana to Venezuela.

Figured specimens: Fig. 7, USNM 878005; height 50.8 mm, diameter 26 mm; off Guyana, 45-54 m. Fig. 8, Vokes Coll. (paratype); height 34.2 mm, diameter (including spines) 16.3 mm; locality *Oregon* Sta. 2275, off Suriname. Fig. 9, PRI 26200 (paratype – *M. olssoni* Vokes); height (incomplete) 50 mm, diameter 33 mm; locality, Cabo Blanco, Venezuela.

Discussion: In the original description of *H. olssoni* (Vokes, 1967a, p. 84), specimens from the Plio-Pleistocene of Venezuela at Punta Gavilan and Cabo Blanco were included in that species. However, examination of material from these formations in the collections of the Naturhistorisches Museum Basel shows the shells to have a keeled protoconch, which is characteristic of *H. donmoorei* (compare pl. 2, figs. 6 and 8), as well as the wider body whorl with four or five axial ridges in contrast to the three generally present in *H. olssoni*. A few specimens also show several spines on the siphonal canal.

HAUSTELLUM OLSSONI (Vokes)
Plate 2, figures 5, 6

Murex recurvirostris Broderip. GABB, 1881, Acad. Nat. Sci. Phila., Jour., (Ser. 2) v. 8, pt. 4, p. 349 (not of Broderip).

Murex (Murex) olssoni VOKES, 1967, Tulane Stud. Geol., v. 5, no. 2, p. 84 [in part, not all localities], pl. 3, figs. 1, 2 only [fig. 3 = *H. donmoorei* (Bullis)]; BAYER, 1971, Bull. Mar. Sci., v. 21, no. 1, p. 151, text-fig. 24.

Murex olssoni Vokes. RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 69, pl. 7, fig. 6, pl. 14, fig. 8; FAIR, 1976, The Murex Book, p. 64, pl. 2, fig. 14 (holotype).

Holotype: USNM 677704; height 52 mm, diameter (excluding spines) 23 mm.

Type locality: *Oregon* Station 4896, Gulf of Morrosquillo, Colombia, 23-27 fms (42-49 m).

Occurrence: Tubará Group, Colombia; Moín Formation, Costa Rica. Recent, off Panama and Colombia.

Figured specimens: Fig. 5, USNM 450347; height 38.5 mm, diameter (including spines) 23.8 mm; locality TU 954. Fig. 6, USNM 878004; height 17.6 mm, diameter (excluding spines) 7.6 mm; locality TU R-101. Additional localities: TU 953, 956, 1239, 1240, 1307, 1495, 1496.

Discussion: When this species was originally described, we had only a small amount of fossil material collected by Axel Olsson in what he termed the "upper Gatun formation" at Puerto Limón. Since that time we have collected extensively in the Limón area and we now recognize two units: the "upper Gatun," which is the mid-Pliocene Río Banano Formation; and the Moín Formation, which is the "coralline limestone" of Olsson (1922) and is younger – Early to mid-Pleistocene in age. The species of *Haustellum* in the Río Banano is *H. messorius* and that in the Moín is *H. olssoni*. This is a result of environment rather than age, as both species are still present in the southern Caribbean; however, *H. olssoni* lives in water averaging about 60 meters in depth (see Bayer, 1971, p. 151, for an extensive list of stations) in contrast to the much shallower habitat of *H. messorius*.

At the time of the original description, specimens from the Punta Gavilan and Mare formations of Venezuela were included. As discussed above, these are now referred to *H. donmoorei*. Specimens from the Agueguexquite Formation, Mexico, are better placed in *H. bellegladensis* (see below).

Although this species is most abundant in the Pleistocene Moín Formation (we have hundreds of specimens from numerous localities), in the collections of the Museum of Paleontology, University of California, Berkeley, there are two specimens from the Tubará Group at Punta Pua (about 25 km northeast of Cartegena, Depto. de Bolívar), Colombia. The presence of this species, known elsewhere only from the Pleistocene and Recent Fauna, is one of the reasons for dating the upper Tubará Group as also Pleistocene in age.

It would appear that *H. olssoni* and *H. donmoorei* occupy approximately the same ecologic niche, with no known overlap in distribution. According to Bayer (1971, pp. 151-152) *H. olssoni* is found off Panama and Colombia, and *H. donmoorei* is taken from off Venezuela east to the Guianas. However, *H. olssoni* lives in somewhat deeper water (about 60 meters, average, in contrast to about 40 meters, average, for *H. donmoorei*, according to Bayer).

HAUSTELLUM ANNIAE (M. Smith)
Plate 3, figures 1-3

Murex (Murex) anniae Smith. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 110, pl. 4, fig. 2.

Murex anniae Smith. RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 61 [in part], pl. 11, fig. 6 only [pl. 7, fig. 15 = *H. bellegladeensis* (Vokes)]; FAIR, 1976, The Murex Book, p. 21, pl. 3, fig. 42 [same specimen figured herein, pl. 3, fig. 1]; PETUCH, 1988, Neogene History Trop. Amer. Moll., p. 154, pl. 32, fig. 6 [also specimen figured herein, pl. 3, fig. 1].

Synonym:

Murex lindajoyceae PETUCH, 1987, New Caribbean Moll. Faunas, p. A1, pl. 29, figs. 1-3.

Holotype: Florida State Museum, US 1350; height 33 mm, diameter 20 mm (*fide* Smith, 1940, p. 44).

Type locality: Bermont Formation; Ortona Lock, Caloosahatchee River, Florida (= TU 79) (*fide* Clench and Pérez Farfante, 1945, p. 6).

Occurrence: Bermont Formation, Florida. Recent, Florida and Yucatán Peninsula.

Figured specimens: Fig. 1, USNM 608528; height 36 mm, diameter (excluding spines) 16 mm; locality, off Yucatán Peninsula. Fig. 2, USNM 878006; height 32.3 mm, diameter (excluding spines) 13 mm; locality TU R-42. Fig. 3, USNM 450348; height 37.5 mm, diameter (excluding spines) 16.3 mm; locality TU 759. Other occurrences: TU localities 79, 539A, 768, 802, 803, 816, 939, 1512.

Discussion: The name *Murex anniae* is the oldest taxon in a group of four closely related species (*anniae, lindajoyceae, bellegladeensis,* and *sallasi*), and for this reason is often used as the name for other members of the group. It is entirely possible that these four represent variations of the same biologic species, but they do have certain geologic and geographic distinctions and I prefer to keep them separate, while bearing in mind the fact that they may be synonyms.

Originally *H. anniae* was described without locality or stratigraphic information. When I originally treated the species (Vokes, 1963a, p. 110) there were only about five specimens known. Three of these are from locality TU 531, at which the other material seems to be from the Caloosahatchee beds, and for this reason I assigned the species to the Caloosahatchee Formation. However, at all Florida spoilbank localities there is always the possibility of more than one formation being present, as it is at the nearby locality TU 283 (just across the road and railroad from TU 531). This seems to be the case, for in all of our subsequent collecting *H. anniae* has been found exclusively in the Bermont Formation, all in western Florida, and almost all along the Caloosahatchee River.

This group of four "species" is marked by having lost the "typical" *Haustellum* rugae on the inner lip, evidently a fairly recent (geologically speaking) development. As noted below, in *H. bellegladeensis* the stratigraphically older specimens commonly have these rugae and in one intermediate specimen, taken to be the "ancestral" *H. anniae,* these rugae are also present.

Although it is difficult to separate the two forms, *H. anniae* is generally recognizable by the greatly reduced strength of the varices. The spines seem to arise from the body itself, rather than being set upon the raised varical ridges (compare pl. 3, figs. 1 and 7, for example) but the individual spines themselves are longer. The intervarical nodes also are less swollen, giving the shell an "emaciated" appearance.

In the fossil record, *H. anniae* and *H. bellegladeensis* do not occur together. There must be some ecologic difference that separates the two, for *H. anniae* is found only in western Florida and *H. bellegladeensis* in eastern Florida. Thus, they might be considered valid geographic subspecies. But, in the Recent fauna this is not the case. Today *H. anniae* occurs on both sides of the Florida peninsula and off Yucatán (pl. 3, fig. 1). This form is especially common in the material dredged off the western coast of Florida (TU R-42) in depths of about 45 meters. These specimens have been named *Murex lindajoyceae* by Petuch (1987, p. A1, pl. 29, figs. 1-3), who considers that *H. anniae* is "a much larger and more robust shell with only two intervarical ribs" (compare pl. 3, figs. 2 and 3). The number of intervarical ribs is not a constant feature. Many specimens of *H. anniae* have three intervarical ridges; generally two are stronger, with the most adapertural one reduced.

HAUSTELLUM BELLEGLADEENSIS (Vokes)
Plate 3, figures 4-8

Murex (Murex) recurvirostris Broderip. PER-

RILLIAT MONTOYA, 1960, Paleontología Mexicana, no. 8, p. 21, pl. 3, figs. 10, 11 (not of Broderip).

Murex (Murex) anniae bellegladeensis VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 111, pl. 4, fig. 1.

Murex bellegladeensis Vokes. FAIR, 1976, The Murex Book, p. 25, pl. 3, fig. 32 (same specimen figured herein, pl. 3, fig. 6); PETUCH, 1988, Neogene History Trop. Amer. Moll., pl. 23, fig. 16 (not in text).

Murex anniae Smith. RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 61 [in part], pl. 7, fig. 15 only.

Holotype: USNM 643758; height 40 mm, diameter (excluding spines) 20.5 mm.

Type locality: TU 201, Bermont Formation; two mi south of Belle Glade, Palm Beach County, Florida.

Occurrence: Agueguexquite Formation, Mexico; Caloosahatchee and Bermont formations, Florida; post-Pleistocene, Louisiana. Recent, from Savannah, Georgia, to Galveston, Texas.

Figured specimens: Fig. 4, USNM 450349; height 38.3 mm, diameter 19.3 mm; locality TU 539B. Fig. 5, USNM 450350; height 41.5 mm, diameter 22.5 mm; locality TU 727. Fig. 6, USNM 450351; height 27.9 mm, diameter (excluding spines) 16 mm; locality TU 201. Fig. 7, USNM 878007; height 37.4 mm, diameter 20.5 mm; locality TU R-42. Fig. 8, USNM 450352; height 31.4 mm, diameter 21 mm; locality TU 1046. Additional localities; TU 580, 638, 725, 733, 747, 751, 977, 978, 1023.

Discussion: As noted in the original description, *H. bellegladeensis* is closely related to the Recent *H. sallasi* (Rehder and Abbott). The latter, confined to the area off the east coast of the Yucatán Peninsula, is a narrower shell with almost no varical spines. It is possible that these two forms are synonyms but geologically the more inflated, spinose *H. bellegladeensis* first occurs in the mid-Pliocene Agueguexquite Formation of Mexico. It is common here, originally reported as *Murex recurvirostris* Broderip by Perrilliat Montoya (1960, p. 21, pl. 3, figs. 10, 11); we have many specimens from her locality (= TU 1046) and our locality TU 638. In some Mexican specimens there are still faint rugae on the inner lip, indicating that this is the ancestral form from which all of the varieties being discussed here are derived originally. For this reason, I prefer to maintain the name *H. bellegladeensis,* even though it may actually be a synonym of the older taxon.

In the Tulane Collections from locality TU 539B (Shell Creek, Florida), we have one specimen (pl. 3, fig. 4) that has fairly strong rugae (for the species). Shell Creek is one of the few places in southern Florida where it is (?was) possible to collect in-place material and this shell was found in the Caloosahatchee portion of the section. It is intermediate between typical *H. bellegladeensis,* with heavy varices and intervarical nodes, and *H. anniae* with weak nodes and diminished varices. From the stratigraphical placement of the specimen, it may reveal the beginning of the separation of the *H. anniae* form. Whether it should be referred to *H. bellegladeensis* or to *H. anniae* is a matter of choice, but I consider it closer to *H. bellegladeensis* than to *H. anniae* and, therefore, it is included with this species.

Most specimens of *H. bellegladeensis* and *H. anniae* are easy to separate, but there are occasional long-spined examples of *H. bellegladeensis* that are very like *H. anniae.* Once again, because the *H. bellegladeensis* morph is clearly the ancestral form, I prefer to maintain the species distinction.

As mentioned above, the two forms do not occur together in the Bermont Formation with *H. bellegladeensis* being confined to eastern Florida. In the Recent fauna, however, typical inflated *H. bellegladeensis* occurs off Savannah, Georgia, to off Galveston, Texas. Numerous bright orange specimens have been collected from the "scallop-dumps" in material originally dredged off the east coast of Florida in depths of about 30 meters. It is also common in the material from "Mud-lump 90" (TU 977), which was deposited in water depths of about 60 meters (Morgan, *et al.,* 1963, p. 41) on the basis of the depth ranges of the microfauna.

HAUSTELLUM SALLASI (Rehder and Abbott)
Plate 3, figure 9

Murex recurvirostris sallasi REHDER and ABBOTT, 1951, Soc. Malac. "Carlos de la Torre" (Habana), Rev., v. 8, no. 2, p. 58, pl. 9, figs. 7, 8; VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 96.

Murex sallasi Rehder and Abbott. FAIR, 1976, The Murex Book, p. 74, pl. 3, fig. 37 (holotype).

Holotype: USNM 597515; height 50 mm, diameter 23 mm.

Type locality: Approximately 60 mi northwest of Cabo Catoche, Quintana Roo, Mexico, 18-20 fms (33-37 m).

Occurrence: Recent only, off northeastern Yucatán Peninsula.

Figured specimen: USNM 878008; height 36.4 mm, diameter 21 mm; locality, off Cabo Catoche, Quintana Roo, Mexico.

Discussion: This species, which may be a senior synonym of *H. bellegladeensis,* is confined to the type area. All specimens seen come from this small area; most have been taken by shrimpers. *Haustellum sallasi* is the least spinose of the group of four species under consideration, and also has a narrower body and higher spire than any of the other forms.

HAUSTELLUM CABRITII (Bernardi)
Plate 3, figures 10-12

Murex cabritii BERNARDI, 1859, Jour. de Conchyl., v. 7, p. 30l, pl. 10, fig. 3; RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 63, pl. 10, fig. 12; FAIR, 1976, The Murex Book, p. 28, pl. 3, fig. 39.

Murex (Murex) cabritii Bernardi. CLENCH and PÉREZ FARFANTE, 1945, Johnsonia, v. 1, no. 17, p. 3, pl. 1, figs. 1-3; VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 96; BAYER, 1971, Bull. Mar. Sci., v. 21, no. 1, p. 154, text-fig. 26.

Holotype: Not found; height 65 mm, diameter 25 mm (*fide* Bernardi, 1859, p. 301).

Type locality: Barbados (designated by Clench and Pérez Farfante, 1945, p. 4).

Occurrence: Moín Formation, Costa Rica. Recent, east and west coasts of Florida, Honduras, to Barbados.

Figured specimens: Fig. 10, USNM 450353; height (as is) 30.5 mm; locality TU 953. Fig. 11, USNM 450354; height (incomplete) 18.5 mm, diameter (excluding spines) 11 mm; locality TU 954. Fig. 12, USNM 450355; height (as is) 36.4 mm; locality TU 954. Additional localities: TU 1240, 1307.

Discussion: This well known species has been reported from the fossil record only in passing (Vokes, 1988, p. 20) but there are numerous fragments in the Moín Formation of Puerto Limón, Costa Rica. Today the species lives in water depths of 29-139 meters (16-76 fms) in the Gulf of Mexico (Vokes, 1963a, p. 96) and 18-35 meters off Honduras (David Robinson, personal communication). This latter depth is shallower than the average of 60 meters for living examples of *H. olssoni,* which occurs in great numbers in the same beds. Perhaps the fragmentary condition of fossil specimens of *H. cabritii* is due to post-mortum transportation down-slope.

The generic placement of *H. cabritii* has been discussed in another work (Vokes, 1990a, p. 6) wherein it was noted that the spines on the siphonal canal, the monochromatic color, and the smooth inner lip all point to placement in the genus *Murex* s.s.; however, there is no trace of a labral tooth, and the ornamentation on the early whorls is identical to the other *Haustellum* species (see pl. 3, fig. 11b). It was concluded there that the species is simply the ultimate result of the weakening of the rugae demonstrated in the *H. anniae* group, the increase in spinosity observed in *H. donmoorei,* and the trend toward monochromatic color developed in *H. tryoni* and *H. blakeanus.*

HAUSTELLUM BLAKEANUS (Vokes)

Murex (Murex) blakeanus VOKES, 1967, Tulane Stud. Geol., v. 5, no. 2, p. 88, pl. 4, fig. 1.

Murex blakeanus Vokes. RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 62, text-fig. 34; FAIR, 1976, The Murex Book, p. 26, pl. 1, fig. 8 (paratype).

Holotype: Harvard Mus. Comp. Zool., MCZ 7287; height 43 mm, diameter (excluding spines) 17 mm.

Type locality: *Blake* Station 254, off Grenada, Lesser Antilles, 164 fms (300 m).

Occurrence: Recent only, (?)southern Caribbean.

Discussion: This species was based upon the material that Clench and Pérez Farfante (1945, p. 5, pl. 2) misidentified as "*Murex tryoni.*" They recorded the species from several localities off the coast of Florida. Specimens of true *H. tryoni* are common in deep-water off the coast of Florida, but I have not seen any examples of *H. blakeanus* from there. In fact, I have seen no examples of *H. blakeanus* taken since the original description. It may well be that the records for *H. tryoni* in Clench and Pérez Farfante (1945, p. 6) include specimens of both species and true *H. blakeanus* is confined to the southern Caribbean, as indicated by Radwin and D'Attilio (1976, p. 62).

HAUSTELLUM TRYONI
(Hidalgo *in* Tryon)

Murex (Tribulus) tryoni HIDALGO *in* TRYON, 1880, Manual of Conchology, v. 2, Muricinae, Purpurinae, p. 134, pl. 70, fig. 427.

Murex (Murex) tryoni Hidalgo. CLENCH and PÉREZ FARFANTE, 1945, Johnsonia, v. 1, no. 17, p. 5 [in part], not pl. 2 [= *H. blakeanus* (Vokes)].

Murex (Murex) tryoni Hidalgo. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 96; BULLIS, 1964, Tulane Stud. Zoology, v. 11, no. 4, p. 101; VOKES, 1967, Tulane Stud. Geol., v. 5, no. 2, p. 86, pl. 4, figs. 2 (holotype), 3.

Murex tryoni Hidalgo. RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 74, pl. 7, fig. 19; FAIR, 1976, The Murex Book, p. 84, pl. 2, fig. 24 (specimen figured by Vokes, 1967, pl. 4, fig. 3).

? Synonym:

Murex sunderlandi PETUCH, 1987, New Caribbean Moll. Faunas, p. 98, pl. 21, figs. 5, 6.

Holotype: Acad. Nat. Sci. Philadelphia, ANSP 35355; height 28 mm, diameter (excluding spines) 14 mm.

Type locality: Lesser Antilles.

Occurrence: Recent only, from Florida to Central America and northern South America.

Discussion: A relatively common species in deeper water, *H. tryoni* ranges throughout the Caribbean. Bullis (1964, p. 101) erroneously reported it from *Oregon* Stations 2230 and 2236 (which he incorrectly placed off French rather than British Guiana); however, the correct stations are 2289 and 2291, both off Suriname. Material collected later by the *Oregon* at Station 3636, off British Honduras (Belize) was figured subsequently (Vokes, 1967a, pl. 4, fig. 3).

Petuch (1987, p. 98, pl. 21, figs. 5, 6) has described as *Murex sunderlandi,* specimens that differ from *H. tryoni* in having the intervarical ridges somewhat reduced and with more numerous brown spiral lines. The species is said to be confined to the Goajira Peninsula area of northern Colombia. This material differs little from that which I reported from *Oregon* Station 4398, off the Goajira Peninsula, Colombia, in the aforementioned work (Vokes, 1967a, p. 86). The differences do not seem to be worthy of specific distinction.

Genus CHICOREUS Montfort, 1810

Chicoreus MONTFORT, 1810, Conchyl. Syst., v. 2, p. 611.

Type species: *Murex ramosus* Linné, 1758, by original designation.

Discussion: Houart (written communication, July 1, 1989) has subdivided the Indo-Pacific species of *Chicoreus* into those members with a labral tooth, which he would place in *Chicoreus* s.s., and those without a labral tooth, which he would place in the subgenus *Triplex* Perry, 1810 (type by monotypy: *T. foliatus* Perry, 1810 = *Murex palmarosae* Lamarck, 1822). This distinction works well in the Indo-Pacific but breaks down when one tries to apply it to the Atlantic Ocean. There would be no members of *Chicoreus* s.s. in the western Atlantic; but the other species do not readily fall into *Triplex*. For example, a large group akin to the Recent *C. florifer* (Reeve, 1846) would have to be placed into a new subgenus. The early members of this group resemble the Australian *C. denudatus* (Perry, 1811), which is the type of *Torvamurex* Iredale, 1936, but the Pliocene to Recent members do not fit well into this taxon, as they are characterized by a small rounded aperture with a tightly closed anal notch.

A further problem would be that these subgenera would be equal in rank to *Siratus* and *Phyllonotus,* or the latter taxa would have to become separate genera. Thus, the sense of relationship indicated by treating them as subgenera of *Chicoreus* would be lost. Therefore, a compromise is to consider these sub-groups as "Species Groups," as was done in Ponder and Vokes (1988), to underscore the fact that the members within each group are more closely related to each other than to the members of the other groups.

Species Group 1: *Chicoreus dujardinoides*

CHICOREUS (CHICOREUS) LEPIDOTUS (Vokes)
Plate 4, figure 1

Chicoreus (Chicoreus) lepidotus (Vokes). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 185, pl. 1, fig. 4; VOKES, 1972, Earth Sci., v. 25, no. 3, p. 122, pl. 1, fig. 8.

Holotype: USNM 644371; height 34 mm, diameter 20 mm.

Type locality: TU 554, Chipola Formation; Chipola River at power-line crossing (SW 1/4 Sec. 17, T1N, R9W), Calhoun County, Florida.

Occurrence: Chipola Formation (lower beds only), Florida.

Figured specimen: USNM 644371 (holotype). Additional localities: TU 810, 830, 1020, 1050.

Discussion: As noted originally, this species is confined to the basal beds of the Chipola Formation, and its "daughter" species, *C. dujardinoides* is normally confined to the upper beds. However, we now have one example of *C. dujardinoides* from locality TU 457 occuring together with about two dozen examples of *C. lepidotus*. The latter species still remains most abundant at the type locality (TU 554; and TU 1050, which is immediately across the river) where we have over 75 specimens. With the facies similarity between localities TU 554 and TU 830, it is surprising that we have but a single specimen from the latter locality.

CHICOREUS (CHICOREUS) DUJARDINOIDES (Vokes)
Plate 4, figure 2

undescribed *Murex*. RICHARDS, 1943, Jour. Paleontology, v. 17, p. 524.

Chicoreus (Chicoreus) dujardinoides (Vokes). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 185, pl. 1, fig. 6; VOKES, 1972, Earth Sci., v. 25, no. 3, p. 122, pl. 1, fig. 9; VOKES, 1989, Bulls. Amer. Paleontology, v. 97, no. 332, p. 33, pl. 2, figs. 10, 11.

Chicoreus dujardinoides (Vokes). VOKES, 1979, Tulane Stud. Geol. Paleont., v. 15, p. 112, pl. 1, figs. 7, 8.

Holotype: USNM 644372; height 32.5 mm, diameter 18.5 mm.

Type locality: TU 547, Chipola Formation; Chipola River (SW 1/4 Sec. 29, T1N, R9W), Calhoun County, Florida.

Occurrence: (?)Baitoa Formation, Dominican Republic; Chipola Formation (*usually* upper beds only), Florida.

Figured specimen: USNM 263955; height 34.5 mm, diameter 19 mm; locality TU 820. Additional localities: TU 457 (one specimen), 459, 553, 555, 818--828, 950, 999, 1048, 1196.

Discussion: In an earlier paper (Vokes, 1979, p. 112) I pointed out that the specimen mentioned by Richards (1943, p. 524) as an undescribed *Murex* from the Gabb Collection was the same as the Chipola *C. dujardinoides* and I suggested that it probably came from the correlative Baitoa Formation in the Dominican Republic. In spite of all the collecting that we have done since that time in the Dominican Republic, we have never collected an example of *C. dujardinoides*. However, we did find a Baitoa locality where another Chipola species also occurs and I believe there is no question that the Gabb specimen came from the Baitoa Formation.

This species is almost totally confined to the upper beds of the Chipola Formation, with the exception of the Dominican specimen and, as noted above, the single example from the basal beds at locality TU 457 (= "one mile below Bailey's Ferry" of Dall, Gardner, etc; see Vokes, 1989a). The species is never common, but it is much more widespread than *C. lepidotus*. Along Farley Creek, to the east of the Chipola River, it occurs at almost every locality, but usually in fragmentary condition.

CHICOREUS (CHICOREUS) CORRIGENDUM Vokes
Plate 4, figure 3

Murex (Phyllonotus) compactus Gabb. VAUGHAN and WOODRING *in* VAUGHAN *et al.*, 1921, Geol. Surv. Dominican Republic, Mon. 1, p. 149 (not of Gabb).

Chicoreus (Chicoreus) compactus (Gabb). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 187 [in part, not of Gabb], pl. 2, fig. 3.

Chicoreus (Chicoreus) corrigendum VOKES, 1989, Bulls. Amer. Paleontology, v. 97, no. 332, p. 34, pl. 3, figs. 3-5.

Holotype: Naturhistorisches Museum Basel, NMB H 17003; height 41 mm, diameter 23.4 mm.

Type locality: NMB 17284, Baitoa Formation; east side of Río Yaque del Norte, at Boca de los Ríos, just below the confluence of the Río Bao and the Río Yaque, Dominican Republic.

Occurrence: Baitoa Formation, Dominican Republic; Cantaure Formation, Venezuela.

Figured specimen: USNM 113775 (paratype); height 36.5 mm, diameter 20 mm; locality unknown. Additional localities: TU 1269, 1364.

Discussion: The name "corrigendum" was selected for this species because the specimen here figured has had a very confused history. It was originally identified in the collections of the U. S. National Museum as *Murex (Phyllonotus) compactus* Gabb, and was said to be from Potrero, on the Río Amina, Dominican Republic. I figured it as such in the *Chicoreus* part of *Cenozoic Muricidae* (Vokes, 1965a). As was shown in the Dominican Republic report (Vokes, 1989b, p. 34) it is neither *C. compactus*, nor is it from Potrero. In that paper it was described as a new species from the Baitoa Formation.

Other than the seven examples in the type lot, all from the Baitoa Formation, we have one specimen from the Early Miocene Cantaure Formation of Ven-

ezuela (TU 1269) originally collected by Mr. Jack Gibson-Smith.

CHICOREUS (CHICOREUS) ENIGMATICUS Vokes
Plate 4, figure 4

Chicoreus (Chicoreus) enigmaticus VOKES, 1989, Bulls. Amer. Paleontology, v. 97, no. 332, p. 37, pl. 6, fig. 4.

Holotype: USNM 323897; height 34.3 mm, diameter 24.6 mm.

Type locality: TU 1422, Cercado Formation; Arroyo Bellaco, which is a tributary of Río Cana from the east, at coral reef that is exposed approximately 1 km below the ford at Las Caobas Adentro, 3 km southwest of Las Caobas, Dominican Republic.

Occurrence: Cercado Formation, Dominican Republic.

Figured specimen: USNM 323897 (holotype).

Discussion: This "enigmatic" species bears only a generic resemblance to the other members of the genus *Chicoreus* and yet there is no question that this is the genus into which it should be placed. Based upon a unique specimen from the reefal facies of the Late Miocene Cercado Formation in the Dominican Republic, we can simply note its existence and little more.

PLATE 4

Figures Page

1. *Chicoreus (Chicoreus) lepidotus* (Vokes) (X 1 1/2) 24
USNM 644371; height 34 mm, diameter 20 mm.
Locality: TU 554, Florida; Chipola Formation.

2. *Chicoreus (Chicoreus) dujardinoides* (Vokes) (X 1 1/2) 25
USNM 263955; height 34.5 mm, diameter 19 mm.
Locality: TU 820, Florida; Chipola Formation.

3. *Chicoreus (Chicoreus) corrigendum* Vokes (X 1 1/2) 25
USNM 113775 (paratype); height 36.5 mm, diameter 20 mm.
Locality: Unknown, Dominican Republic; Baitoa Formation.

4. *Chicoreus (Chicoreus) enigmaticus* Vokes (X 1 1/2) 26
USNM 323897 (holotype); height 34.3 mm, diameter 24.6 mm.
Locality: TU 1422, Dominican Republic; Cercado Formation.

5. *Chicoreus (Chicoreus) cosmani* Abbott and Finlay (X 2) 28
USNM 323863; height 28.5 mm, diameter 11.7 mm.
Locality: TU 1215, Dominican Republic; Gurabo Formation.

6. *Chicoreus (Chicoreus) xestos* Vokes (X 1 1/2) 28
USNM 647115 (paratype); height 30.5 mm, diameter 16.5 mm.
Locality: TU 1000, Florida; Pinecrest Beds.

7. *Chicoreus (Chicoreus) prolixus* Vokes (X 1 1/4) 32
USNM 647117 (holotype); height 49 mm, diameter (excluding spines) 23.5 mm.
Locality: TU 954, Costa Rica; Moín Formation.

8. *Chicoreus (Chicoreus) shirleyae* Vokes (X 1) 28
USNM 450356; height 65.4 mm, diameter 36.3 mm.
Locality: TU 729, Florida; Pinecrest Beds.
(Color pattern under ultraviolet light)

9, 12. *Chicoreus (Chicoreus) floridanus* Vokes 29
9. (X 1 1/4) USNM 450357; height 49.2 mm, diameter 28.3 mm.
Locality: TU 1000, Florida; Pinecrest Beds.
12. (X 1 1/2) USNM 450358; height 42 mm, diameter 23.7 mm.
Locality: TU 729, Florida; Pinecrest Beds.
(Color pattern under ultraviolet light)

10, 11. *Chicoreus (Chicoreus) dilectus* (Adams) 29
10. (X 2) USNM 450359; height 27.4 mm, diameter 15.2 mm.
Locality: TU 1046, Mexico; Agueguexquite Formation.
11. (X 1) USNM 654369; height 54 mm, diameter (excluding spines) 26.5 mm.
Locality: off Long Boat Key, Florida; Recent.

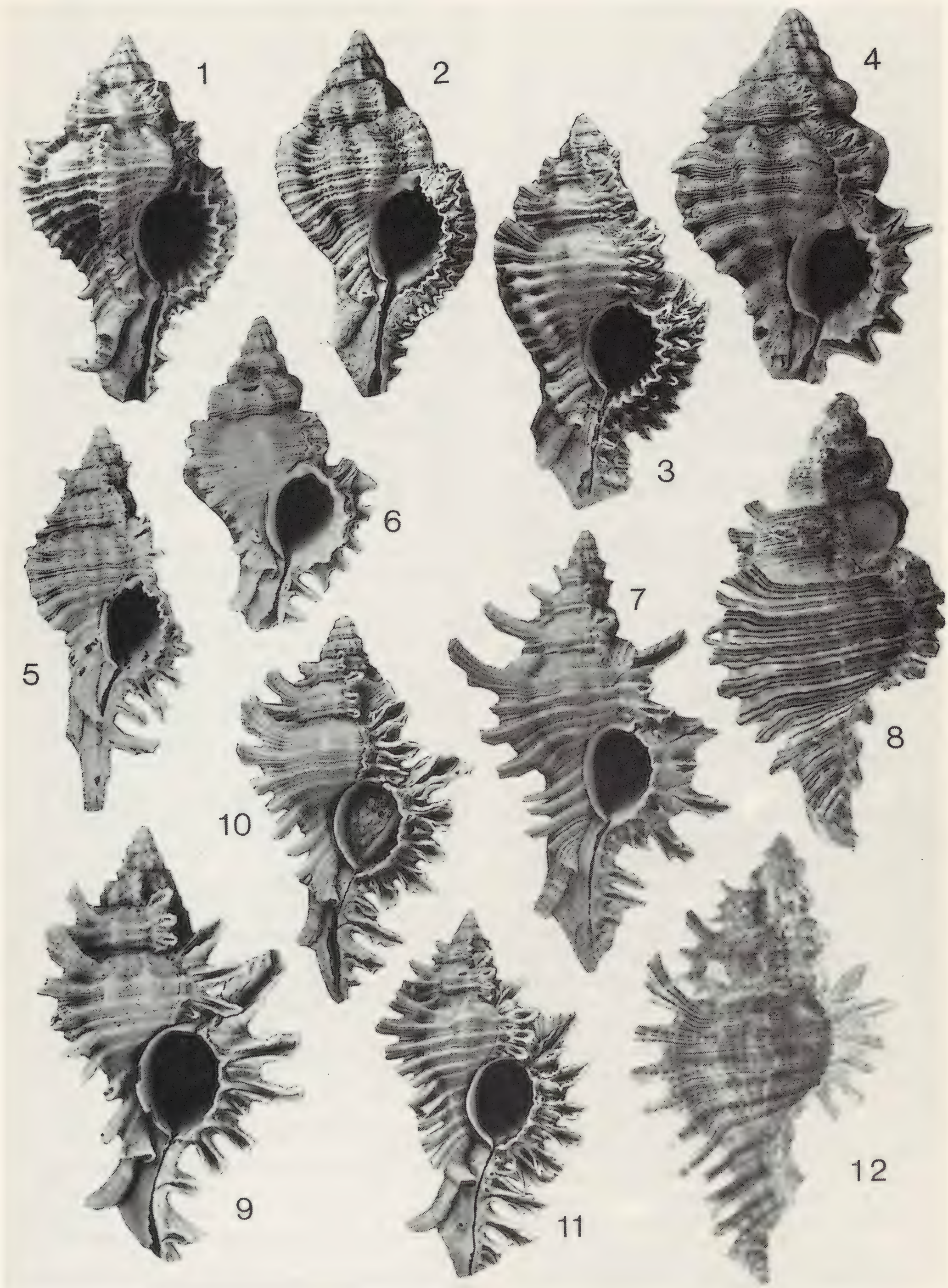


PLATE 4

Chicoreus (Chicoreus) cosmani
Abbott and Finlay
Plate 4, figure 5

Murex spectrum Reeve. HUMFREY, 1975, Sea Shells West Indies, p. 131, pl. 15, figs. 10, 10a (not of Reeve).

Chicoreus cosmani ABBOTT and FINLAY, 1979, Nautilus, v. 93, p. 159, text-figs. 1-9.

Chicoreus (Chicoreus) cosmani Abbott and Finlay. VOKES, 1989, Bulls. Amer. Paleontology, v. 97, no. 332, p. 35, pl. 2, fig. 4.

?Synonym:

Murex pudoricolor REEVE, 1845, Conch. Icon., v. 3, *Murex,* pl. 33, fig. 171; REEVE, 1846, Zool. Soc. London, Proc., pt. 13 (1845), p. 108.

Chicoreus pudoricolor (Reeve). FAIR, 1976, The Murex Book, p. 69, pl. 6, figs. 73, 73a.

Chicoreus species. ABBOTT and FINLAY, 1979, Nautilus, v. 93, p. 161, text-figs. 10, 11.

Holotype: USNM 783323; height 79 mm, diameter 40 mm.

Type locality: Ocho Rios, Jamaica, 10-15 ft (3-4.5 m).

Occurrence: Gurabo Formation, Dominican Republic. Recent, Jamaica to Virgin Islands, (?)Netherland Antilles.

Figured specimen: USNM 323863; height 28.5 mm, diameter 11.7 mm; locality TU 1215.

Discussion: A single specimen from a coral-reef locality in the Gurabo Formation, Dominican Republic, is the entire fossil record of this species, which has only recently been recognized in the fauna of the Caribbean.

A specimen collected from Curaçao, Netherland Antilles, was identified by Fair (1976, p. 69) as *C. pudoricolor* (Reeve). The original illustration of Reeve's species is poor, and the type specimen cannot be located. Abbott and Finlay (1979, p. 162) suggest that this specimen may be "a darkly striped, less beaded form of *C. cosmani*" rather than *C. pudoricolor,* which they believe is closer to a young *C. spectrum.* The Curaçao specimen has more resemblance to the Reeve illustration than to specimens of *C. cosmani,* which have a longer siphonal canal and generally four intervarical ridges. Just what the relationship of the Curaçao specimen is to either *C. pudoricolor* or *C. cosmani* is not known. De Jong and Coomans (1988, p. 72) had no specimens of this form from Curaçao; they simply repeat the information given above.

Although Abbott and Finlay relate *C. cosmani* to the Australian species *C. akritos* Radwin and D'Attilio, 1976, there is not much more than a generic relationship. But they are correct in the fact that *C. cosmani* is closer to the Indo-Pacific species of *Chicoreus* than to the western Atlantic ones.

Chicoreus (Chicoreus) xestos Vokes
Plate 4, figure 6

Chicoreus (Chicoreus) xestos VOKES, 1974, Tulane Stud. Geol. Paleont., v. 11, no. 2, p. 86, pl. 2, figs. 1, 2.

Holotype: USNM 647114; height 42.3 mm, diameter (excluding spines) 21.7 mm.

Type locality: TU 1000, Pinecrest Beds; road-metal pits (now APAC), at end of 17th St., about 8 mi east of U.S. Highway 301 (T36S, R19E), at Sarasota, Sarasota County, Florida [now just north of Fruitville Road exit, on west side of highway I-75].

Occurrence: Pinecrest Beds, Florida.

Figured specimen: USNM 647115 (paratype); height 30.5 mm, diameter 16.5 mm; locality TU 1000.

Discussion: The extensive pits at Sarasota have yielded a few more examples of *C. xestos,* but this remains the only locality for the species. As the name implies, *C. xestos* (L., smooth) may be distinguished from *C. floridanus* Vokes, with which it occurs, by the smoother surface. But more importantly it is characterized by having a denticulate aperture with a broadly open anal notch, in contrast to the rounded, non-denticulate aperture with a very constricted anal notch, typical of *Chicoreus floridanus.*

Species Group 2: *Chicoreus florifer*

Chicoreus (Chicoreus) shirleyae Vokes
Plate 4, figure 8

Chicoreus (Chicoreus) shirleyae VOKES, 1966, Tulane Stud. Geol., v. 5, no. 1, p. 36, text-fig. 1.

Chicoreus shirleyae Vokes. PETUCH, 1988, Neogene History Trop. Amer. Moll., pl. 14, fig. 10 (not in text).

Holotype: USNM 645147; height 88 mm, diameter 39 mm.

Type locality: TU 729, Pinecrest Beds; west side of Kissimmee Canal, east side of Kissimmee River, approximately 1/2 mi south of U. S. Corps of Engineers Structure 65-D (S 1/2 Sec. 33, T36S, R33E), Okeechobee County, Florida.

Occurrence: Pinecrest Beds (lower portion only), Florida.

Figured specimen: USNM 450356; height 65.4 mm, diameter 36.3 mm; locality TU 729.

Discussion: The material discussed in the original description remains the only record of this unusual species. Petuch (1988b, pl. 14, fig. 10) has figured a specimen said to be from the "Buckingham Formation, Sarasota, Florida" (= Pinecrest Beds, TU 1000), but in all of the material I have seen from that locality there are no specimens of *C. shirleyae*. This species occurs with *Vasum olssoni* Vokes, 1966, which also has not been found at Sarasota. I think the reason for the restriction to the Kissimmee area is time and not facies, since many other species are found in both places.

The color pattern of *C. shirleyae* (as revealed by ultra-violet light – pl. 4, fig. 8) is similar to that of *C. floridanus*, with numerous fine dark spiral threads topping each of the spiral cords.

Chicoreus (Chicoreus) floridanus Vokes
Plate 4, figures 9, 12

Chicoreus (Chicoreus) floridanus VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 189, pl. 3, figs. 1-3.

Chicoreus floridensis [*sic*] Vokes. PETUCH, 1988, Neogene History Trop. Amer. Moll., pl. 13, fig. 4 (not in text).

Holotype: USNM 644823; height 73 mm, diameter 38 mm

Type locality: TU 520, Pinecrest Beds; canal 0.9 mi [not 1/3 mi as stated in original description] east of Brighton, Highlands County, Florida.

Occurrence: Jackson Bluff, Pinecrest, and Caloosahatchee formations, Florida; Waccamaw Formation, North and South Carolina.

Figured specimens: Fig. 9, USNM 450357; height 49.2 mm, diameter 28.3 mm; locality TU 1000. Fig. 12, USNM 450358; height 42 mm, diameter 23.7 mm; locality TU 729. Additional localities: TU 726, 728-30, 736, 737, 740, 742, 752, 755, 767-70, 796, 797, 801, 802, 870, 932, 933, 939, 974, 975, 980, 991, 1023, 1044, 1174, 1175, 1177, 1349, 1491-93, 1512, 1524.

Discussion: In the original description of *C. floridanus* the observation was made that the species was ubiquitous in the "upper Miocene and Pliocene" of the southeastern United States (Vokes, 1965a, p. 190). With the ages of the formations shifted upward (see above), the statement now should read "ubiquitous in the Middle Pliocene to Early Pleistocene;" other than that nothing has changed.

This species has been presumed to be ancestral to the Gulf of Mexico *C. dilectus* (Adams) and the Caribbean *C. florifer*. But, a question is raised by the presence in the Middle Pliocene (N.20) Agueguexquite Formation, Veracruz, Mexico, of specimens that are the same as those recently named *C. rachelcarsoni* by Petuch (1987). These specimens have only one intervarical node, as in the Recent *C. dilectus*, and only five varical fronds. The number of fronds is probably not significant, many examples of *C. floridanus* have only five fronds (see pl. 4, fig. 9) but the presence of a single intervarical node is. It is my belief that *C. rachelcarsoni* is a synonym of *C. dilectus*, and, thus, this species first appears in the mid-Pliocene Agueguexquite Formation, a more southerly sibling species of *C. floridanus* rather than a linear descendant.

This would mean that the southern form moved into Florida after glacial cooling had wiped out the older *C. floridanus*, explaining why the two species are never found together. The Recent *C. florifer*, with one very large intervarical node, may be an offshoot of the *C. dilectus* lineage rather than the *C. floridanus* lineage. As many people believe that the two Recent forms are synonymous, this is a reasonable assumption.

The color pattern of *C. floridanus* (as revealed by ultra-violet light – pl. 4, fig. 12) is unlike any living Caribbean species, having what seems to have been a light-colored shell, with numerous dark spiral threads topping each of the spiral cords. This type of pattern is found in a number of Indo-Pacific species, such as *C. palmaerosae* (Lamarck, 1822), but this is almost certainly only parallelism, for the aperture indicates that *C. floridanus* is closely related to *C. dilectus* and *C. florifer*.

Chicoreus (Chicoreus) dilectus (Adams)
Plate 4, figures 10, 11

Chicoreus (Chicoreus) dilectus (A. Adams). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 191, pl. 3, fig. 4; text-fig. 2 (lectotype).

Chicoreus florifer (Reeve). RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 37 [in part, not of Reeve], pl. 6, fig. 7 only.

Chicoreus dilectus (A. Adams). FAIR, 1976, The Murex Book, p. 37, pl. 7, fig. 84.

Synonym:

Chicoreus (Chicoreus) dilectus (A. Adams) variety. VOKES, 1974, Tulane Stud. Geol. Paleont., v. 11, no. 2, p. 87, pl. 2, figs. 3, 4.

Chicoreus dilectus (A. Adams) variety. FAIR, 1976, The Murex Book, p. 37, pl. 7, fig. 85.

Chicoreus rachelcarsonae PETUCH, 1987, New Caribbean Moll. Faunas, p. 13, pl. 1, figs. 9, 10; PETUCH, 1988, Neogene History Trop. Amer. Moll., pl. 31, fig. 11 (not in text).

Lectotype: Brit. Mus. (Nat. Hist.), BMNH 1965-9 (designated by Vokes, 1965a, p. 191); height 55 mm, diameter (excluding spines) 27 mm [not 37 mm, as stated in Vokes, 1965a, p. 191].

Type locality: Sanibel Island, Florida (designated by Clench and Pérez Farfante, 1945, p. 35, for *Murex florifer arenarius*, a synonym).

Occurrence: Agueguexquite Formation, Veracruz, Mexico; Bermont and Anastasia formations, Florida. Recent, Gulf of Mexico.

Figured specimens: Fig. 10, USNM 450359; height 27.4 mm, diameter 15.2 mm; locality TU 1046. Fig. 11, USNM 654369; height 54 mm, diameter (excluding spines) 26.5 mm; locality, off Long Boat Key, Florida. Additional localities: TU 79, 638, 725, 727, 731, 733, 743, 746-48, 750, 759, 767, 768, 788, 791, 802, 803, 939,973, 978, 990.

Discussion: The question of whether the Gulf of Mexico *C. dilectus* and the Caribbean *C. florifer* are the same biologic species has troubled writers for years. As there is a valid geographic separation, perhaps subspecific rank would be more appropriate. But this is complicated by the fact that the junior name (*C. dilectus*) is the older species (geologically speaking), first occurring in the Middle Pliocene (zone N.20) Agueguexquite Formation of Veracruz, Mexico.

The specimens that are found in the Agueguexquite are somewhat atypical, in that they have only five fronds on the varices of the body whorl, in contrast to six normally present in most specimens of *C. dilectus*. But I do not believe this is a significant difference. There are populations living today off the coast of western Florida

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PLATE 5

Figures — Page

1. *Chicoreus (Chicoreus) elusivus* Vokes (X 1 1/4) 33
   USNM 647110 (holotype); height 44.6 mm, diameter (excluding spines) 21 mm.
   Locality: TU 547, Florida; Chipola Formation.
2. *Chicoreus (Chicoreus)* sp. cf. *clausi* (Dunker) (X 1 1/2) 37
   USNM 365143; height 33.2 mm, diameter 23.9 mm.
   Locality: TU 1352, Dominican Republic; Mao Formation.

3-5, 10. *Chicoreus (Chicoreus) venezuelanus* (Hodson) 35
   3. (X 1 1/4) PRI 24101 (paratype); height 48.5 mm, diameter 30 mm.
      Locality: Urumaco, Venezuela; Urumaco Formation.
   4. (X 10) USNM 450360; height 20.3 mm, diameter 12 mm.
      Locality: TU 589, Costa Rica; Río Banano Formation.
   5. (X 3/4) USNM 450361; height 71.6 mm, diameter (including spines) 49.3 mm.
      Locality: TU 589, Costa Rica; Río Banano Formation.
   10. (X 1 1/4) USNM 450362; height (as is) 24.8 mm, diameter (as is) 23.5 mm.
      Locality: TU 959, Panama; Gatun Formation.

6. *Chicoreus (Chicoreus) brevifrons* (Lamarck) (X 1 1/2) 34
   USNM 450363; height 41.7 mm, diameter 22.1 mm.
   Locality: TU 69A, Florida; Shoal River Formation.
7. *Chicoreus (Chicoreus) cornurectus* (Guppy) (X 1 1/2) 33
   USNM 323862; height 45 mm, diameter 26.5 mm.
   Locality: TU 1211, Dominican Republic; Gurabo Formation.
8. *Chicoreus (Chicoreus) jungi* Vokes, n. sp. (X 1) 34
   NMB H 15453 (holotype); height 57.2 mm, diameter 39.5 mm.
   Locality: NMB 10703, Carriacou Island, West Indies; Grand Bay Formation.
9. *Chicoreus (Chicoreus) veronica* Vokes, n. sp. (X 1) 36
   UCMP 38647 (holotype); height 66.6 mm, diameter 40.8 mm.
   Locality: UCMP S-4153, Veronica, Veracruz, Mexico; Agueguexquite Formation.

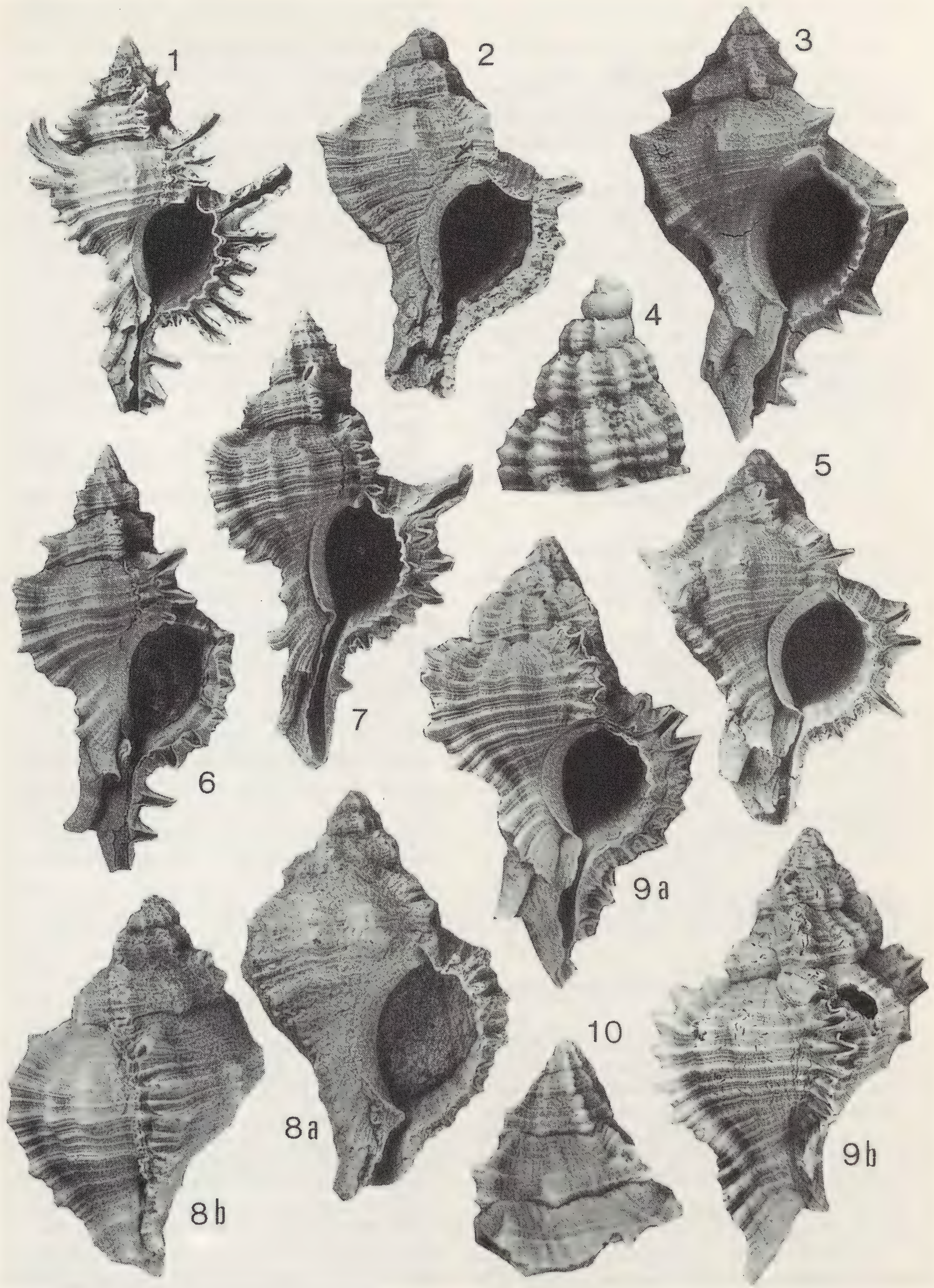

PLATE 5

(see Vokes, 1974a, p. 87, pl. 2, fig. 3) with this same number, which Petuch (1987, p. 13, pl. 1, figs. 9, 10) has named *C. rachelcarsonae*. There are also specimens of *C. florifer* from Roatan, Bay Islands (TU R-503) that have just five fronds and, as noted above, many specimens of *C. floridanus* have only five fronds.

Perhaps the five-frond form is the ancestral type and those modern specimens with only five are atavists. In any case, this is the form found in the Pliocene specimens of the species (pl. 4, fig. 10), which otherwise are identical to the more modern examples. As in the sibling species, *C. floridanus* (above), there is a great deal of variation in the length and width of these fronds. Some specimens have long, thin fronds, others have short, stubby fronds. Again, this is not a significant difference, and at any given locality examples showing every variation occur together.

CHICOREUS (CHICOREUS) FLORIFER (Reeve)

Chicoreus (Chicoreus) florifer (Reeve). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 194, pl. 3, fig. 6.

Chicoreus florifer (Reeve). RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 37 [in part], not pl. 6, fig. 6 [= *C. brunneus* (Link)] or 7 [= *C. dilectus* (Adams)], (?)text-figs. 18 (protoconch), 19 (radula); FAIR, 1976, The Murex Book, p. 43, pl. 9, fig. 119.

Synonym:

Chicoreus emilyae PETUCH, 1987, New Caribbean Moll. Faunas, p. 65, pl. 13, figs. 1, 2.

Lectotype: Brit. Mus. (Nat. Hist.), BMNH 1965-11 (designated by Vokes, 1965a, p. 194); height 75 mm, diameter (excluding spines) 40 mm.

Type locality: Honduras.

Occurrence: Recent only, Bahama Islands to Panama.

Discussion: This Caribbean species differs from the Gulf of Mexico *C. dilectus* in having stronger intervarical nodes and longer shoulder spines, which gives the shell a more triangular aspect. The color is variable, with beautiful bright pink specimens being taken off the Bay Islands, Honduras, and from white with brown fronds, to totally dark brown from most localities.

Specimens with extremely long spines have been named *C. emilyae* by Petuch (1987, p. 65, pl. 13, figs. 1, 2). He compares his species to *C. florifer*, which he considers to be confined to Florida, the Bahamas, and Cuba (although the type locality is Honduras), stating that *C. emilyae*, which "ranges from Roatan Is. south to Panama" is "the southern representative of the *C. florifer-dilectus-rachelcarsonae* species complex." We have many specimens of typical *C. florifer* from Honduras, Costa Rica, and Panama (especially TU R-109, where we have hundreds of specimens), and this does not appear to be a valid distinction.

CHICOREUS (CHICOREUS) DUNNI Petuch

Chicoreus dunni PETUCH, 1987, New Caribbean Moll. Faunas, p. 53, pl. 10, fig. 5 (front view; back view without number on back cover).

Holotype: USNM 859835; height 36 mm, diameter (including spines) 20 mm.

Type locality: Eleuthra Island, Bahama Islands.

Occurrence: Recent only, Bahama Islands.

Discussion: Chicoreus dunni is known only from the type area. It is a small, thin-shelled species, almost black, that is obviously closely related to the *C. florifer* complex, but it does seem to be consistently different. Typical *C. florifer* occurs in the same general area and at the same shallow (1 m) depth, but *C. dunni* occurs only in enclosed shallow ponds that may be hypersaline (Kevan Sunderland, personal communication). All of the shells in these ponds are very thin shelled, and *C. dunni* may be no more than an ecologic variation.

CHICOREUS (CHICOREUS) PROLIXUS Vokes
Plate 4, figure 7

Chicoreus (Chicoreus) prolixus VOKES, 1974, Tulane Stud. Geol. Paleont., v. 11, no. 2, p. 88, pl. 2, fig. 5.

Holotype: USNM 647117; height 49 mm, diameter (excluding spines) 23.5 mm.

Type locality: TU 954, Moín Formation; hill cut immediately behind Standard Fruit Co. box factory, just west of cemetery at Pueblo Nuevo, about 2 km west of Puerto Limón, Costa Rica.

Occurrence: Moín Formation, Costa Rica.

Figured specimen: USNM 647117 (holotype). Additional localities: TU 956, 1239, 1240, 1307.

Discussion: Although we have collected many more examples of this species from four additional localities, there is nothing

to be added to the original discussion. Among these are several juveniles that show a very large two whorl protoconch, as anticipated in the original description.

CHICOREUS (CHICOREUS) MERGUS Vokes

Chicoreus (Chicoreus) mergus VOKES, 1974, Tulane Stud. Geol. Paleont., v. 11, no. 2, p. 91, pl. 3, fig. 2.

Chicoreus mergus Vokes. FAIR, 1976, The Murex Book, p. 58, pl. 9, fig. 114 (holotype).

Holotype: USNM 734375; height 48.8 mm, diameter (excluding spines) 25 mm.

Type locality: Bridgetown, Barbados, 40 fms (73 m).

Occurrence: Post-Pleistocene, Louisiana. Recent, Florida Keys to Costa Rica and northern South America.

Discussion: When described, this species was known only from the Recent fauna. Since then we have collected one example from "Mud-lump 90," at the mouth of the Mississippi River (TU 977), in beds which are dated at about 15,000 YBP, and were deposited in about 60 meters depth (Morgan *et al.*, 1963, p. 41).

In the original description a paragraph was inadvertently omitted in which it was noted that this new species was named "mergus," meaning a diver, in honor of John Phillips, of Goleta, California (at that time), who provided the type specimen.

CHICOREUS (CHICOREUS) BULLISI Vokes

Chicoreus (Chicoreus) bullisi VOKES, 1974, Tulane Stud. Geol. Paleont., v. 11, no. 2, p. 91, pl. 3, fig. 3.

Chicoreus bullisi Vokes. FAIR, 1976, The Murex Book, p. 28, pl. 9, fig. 117 (holotype).

Holotype: USNM 734215; height 65 mm, diameter (excluding spines) 31.5 mm.

Type locality: *Oregon* Station 6456, about 90 mi east of the coast of Nicaragua, 75 fms (137 m).

Occurrence: Recent only, off Nicaragua, so far as known.

Discussion: We have no additional information on this species, which may be only a deep-water variant of *C. mergus*. However, as noted in the original description, the general outline of the shell is more akin to the Pleistocene *C. prolixus*, which as the name implies is extremely high-spired.

Species Group 3: *Chicoreus brevifrons*

CHICOREUS (CHICOREUS) ELUSIVUS Vokes
Plate 5, figure 1

Chicoreus (Chicoreus) elusivus VOKES, 1974, Tulane Stud. Geol. Paleont., v. 11, no. 2, p. 82, pl. 1, figs. 1-4.

Holotype: USNM 647110; height 44.6 mm, diameter (excluding spines) 21 mm.

Type locality: TU 547, Chipola Formation; west bank of Chipola River, about 2000 ft above mouth of Fourmile Creek (SW 1/4 Sec. 29, T1N, R9W), Calhoun County, Florida.

Occurrence: Chipola Formation, Florida.

Figured specimen: USNM 647110 (holotype). Additional localities: TU 999, 1048.

Discussion: Other than a few additional fragments and a few additional localities, this species remains as elusive as when described.

CHICOREUS (CHICOREUS) CORNURECTUS (Guppy)
Plate 5, figure 7

Not *Murex (Phyllonotus) cornurectus* Guppy. OLSSON, 1922, Bulls. Amer. Paleontology, v. 9, no. 39, p. 131(303) [= *C. venezuelanus* (Hodson)].

Chicoreus (Chicoreus) cornurectus (Guppy). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 186 [in part, not including Chipola specimens = *C. elusivus* Vokes], pl. 2, fig. 2, text-fig. 1 (lectotype); VOKES, 1974, Tulane Stud. Geol. Paleont., v. 11, no. 2, p. 84; VOKES, 1989, Bulls. Amer. Paleontology, v. 97, no. 332, p. 31, pl. 2, figs. 6-9.

Murex (Chicoreus) cf. *brevifrons* Lamarck. JUNG, 1969, Bulls. Amer. Paleontology, v. 55, no. 247, p. 491, pl. 49, fig. 7.

Not *Chicoreus (Chicoreus) cornurectus* (Guppy). JUNG, 1971, Bulls. Amer. Paleontology, v. 61, no. 269, p. 192, pl. 10, figs. 8, 9 [= *C. jungi* Vokes, n. sp.]

Lectotype: Brit.Mus. (Nat. Hist.), BMNH GG. 20254 (designated by Vokes, 1965a, p. 186); height 89.2 mm, diameter 45 mm.

Type locality: NMB 17287, Baitoa Formation; east side of Río Yaque del Norte, at Boca de los Ríos, just below the confluence of the Río Bao and the Río Yaque, Dominican Republic (restricted by Vokes, 1989b, p. 32).

Occurrence: Baitoa, Cercado, Gurabo and Mao formations, Dominican Republic; Cantaure Formation, Venezuela; Pirabas Limestone, Brazil; (?)Quebradillas Limestone, Puerto Rico; Gatun Formation, Panama; Melajo Clay and Courbaril Beds, Trinidad.

Figured specimen: USNM 323862; height 45 mm, diameter 26.5 mm; locality TU 1211. Addi-

tional localities: TU 757, 960; for localities in the Dominican Republic, see Vokes, 1989b, p. 33.

Discussion: Chicoreus cornurectus is widespread in the Dominican Republic, occurring at almost every locality in the more shallow-water beds. It has also been reported [under the name *Chicoreus brevifrons* (Lamarck, 1822)] from the Cantaure Formation of Venezuela (Jung, 1965, p. 521), from the Pirabas Limestone of Brazil (Maury, 1925, p. 139, pl. 6, fig. 7), from the Gatun Formation of Panama (Woodring, 1959, p. 216, pl. 35, fig. 12) and the Melajo Clay and Courbaril Beds of Trinidad (Jung, 1969, p. 491, pl. 49, fig. 7).

In the Dominican Republic report (Vokes, 1989b, p. 33), I listed the species as occurring at Naturhistorisches Museum Basel localities NMB 15824 and 15832; however, I placed them in the Cercado/Gurabo formation. Both localities are in the Mao Formation along the lower reaches of the Río Gurabo and these two specimens (one adult and one juvenile) document the only occurrence of this species in the Mao Formation. We did not collect *C. cornurectus* at any Mao localities.

Chicoreus (Chicoreus) jungi Vokes, n. sp.
Plate 5, figure 8

Chicoreus (Chicoreus) cornurectus (Guppy). JUNG, 1971, Bulls. Amer. Paleontology, v. 61, no. 269, p. 192, pl. 10, figs. 8, 9 (not of Guppy).
unnamed species. VOKES, 1989, Bulls. Amer. Paleontology, v. 97, no. 332, p. 32.

Description: Nature of protoconch and early teleoconch whorls not known; seven whorls of teleoconch preserved in holotype. Spiral ornamentation on body whorl and siphonal canal of six broad raised welts, with between and covering these an array of primary, secondary, and tertiary spiral cords; entire surface of shell covered with minute shagreened threads. Initial number of axial ridges unknown, by third teleoconch whorl the number reduced (from probably 12) to nine, every other one enlarged into a small varix, with the alternating ridges remaining as strong intervarical nodes; five varices per whorl until sixth teleoconch whorl where the number changes to three per whorl, with two strong intervarical nodes between each pair. Varices low, rounded, ornamented by short open spines where crossed by spiral cords, proportional in strength to that of the cord, the six major ones all of equal size. Suture appressed, undulated by axial ornamentation. Aperture elongate-oval; inner lip narrow, smooth, appressed along entire length, but possibly free-standing at anterior end; inner side of outer lip with several elongate lirae. A strong denticle at posterior end on inner lip, forming a broad anal notch. Siphonal canal moderatly long, presumably recurved at distal end; almost closed but open by a narrow slit.

Holotype: Naturhistorisches Museum Basel, H 15453; height 57.2 mm, diameter 39.5 mm.

Type locality: NMB 10703, Grand Bay Formation; Point Saint Hilaire, Carriacou Island, The Grenadines, West Indies.

Etymology of name: In honor of Peter Jung, of the Naturhistorisches Museum, Basel, Switzerland, who collected the type specimen, and for all his work on the Cenozoic faunas of the western Atlantic.

Occurrence: Grand Bay Formation, Carriacou Island.

Figured specimen: NMBH 15453 (holotype).

Discussion: The specimen figured by Jung (1971, pl. 10, figs. 8, 9) as *C. cornurectus* is not that species and is here described. It differs from *C. cornurectus* in having only very short varical spines, all about equal in length. The outline of the body whorl is gently tapering in contrast to the sharp constriction that demarcates the body whorl from the siphonal canal in *C. cornurectus* (compare pl. 5, figs. 7 and 8).

The holotype is poorly preserved so that details of the early development are uncertain. However, it can be seen that the nature of the early varical formation is unusual, with first five alternating varices and intervarical nodes per whorl being developed and only on the penultimate whorl this number being reduced to three varices with two intervarical nodes between each pair.

The Grand Bay Formation represents a mixed fauna, similar to the famous locality at Bowden, Jamaica, with shallow-water mollusks transported down-slope into depths of as much as 200 meters (Jung, 1971, p. 157). There they were deposited along with specimens of planktic foraminifera, which have yielded a good age dating (Robinson and Jung, 1972, p. 124) of Early Middle Miocene (zone N.11), making it correlative with the Shoal River Formation in northwestern Florida.

Chicoreus (Chicoreus) brevifrons (Lamarck)
Plate 5, figure 6

Chicoreus (Chicoreus) brevifrons (Lamarck). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4,

p. 192, pl. 3, fig. 5; VOKES, 1974, Tulane Stud. Geol. Paleont., v. 11, no. 2, p. 84, pl. 1, figs. 5, 6.

Murex (Chicoreus) brevifrons Lamarck. BAYER, 1971, Bull. Mar. Sci., v. 21, no. 1, p. 157, text-figs. 28, 29.

Chicoreus brevifrons (Lamarck). RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 34, pl. 4, fig. 10, text-fig. 15 (protoconch); FAIR, 1976, The Murex Book, p. 27, pl. 9, fig. 115.

Synonym:

Murex spectrum variety *incertum* NOWELL-USTICKE, 1969, Suppl. List New Shells St. Croix, p. 15, pl. 3, fig. 665.

Murex incertum Nowell-Usticke. NOWELL-USTICKE, 1971, Suppl. List New Shells St. Croix, Revised Ed., p. 11, pl. 2, fig. 665.

Chicoreus incertum (Nowell-Usticke). FAIR, 1976, The Murex Book, p. 49.

"Type figure": Martini, 1777, Conchylien-Cab., v. 3, pl. 103, fig. 983 (designated by Clench and Pérez Farfante, 1945, p. 30).

Type locality: St. Thomas, Virgin Islands (designated by Clench and Pérez Farfante, 1945, p. 31).

Occurrence: Shoal River Formation, Florida; Encanto Formation (of Akers, 1972), Oaxaca, Mexico; (?)Tubará Group, Colombia; Punta Gavilan and Mare formations, Venezuela; Pleistocene, Barbados and Curaçao. Recent, Caribbean, exclusive of Florida and the Gulf of Mexico.

Figured specimen: USNM 450363; height 41.7 mm, diameter 22.1 mm; locality TU 69A.

Discussion: This species, which often has been confused with *C. cornurectus*, has not been recognized in most fossil units below the Pleistocene. However, I have figured (Vokes, 1974a, p. 84, pl. 1, fig. 5) a single specimen from beds referred to the Encanto Formation (= locality TU 635; Akers, 1972, p. 11) in Oaxaca, Mexico (from the Gulf of Mexico side of the Continental Divide) and more recently another specimen was collected from the Shoal River Formation, northwestern Florida (locality TU 69A), by Paul Drez (pl. 5, fig. 6). Both of these localities are rather unexpected, inasmuch as today the species does not occur in the Gulf of Mexico but is confined to the Caribbean, where it lives among mangrove roots.

Although not cited by Rutsch (1934), in the collections of the Naturhistorisches Museum, Basel, Switzerland, in material from Punta Gavilan, Venezuela, there is a specimen of *C. brevifrons* and in the collections of the Museum of Paleontology, University of California, Berkeley, there are two specimens from unnamed beds near Usiacuri, Atlantico, Colombia (about halfway between Cartegena and Barranquilla). These beds probably are in the Tubará Group, but it is not certain.

Woodring reported *C. brevifrons* from the Gatun Formation of Panama (1959, p. 216). He figured two different species: one (his pl. 35, fig. 12) is *C. cornurectus;* the other (his pl. 35, figs. 11, 13) is neither *C. brevifrons* nor *C. cornurectus*. Unfortunately the specimen is too poorly preserved to be described.

CHICOREUS (CHICOREUS) VENEZUELANUS (F. Hodson)
Plate 5, figures 3-5, 10

Murex (Phyllonotus) cornurectus Guppy. OLSSON, 1922, Bulls. Amer. Paleontology, v. 9, no. 39, p. 131(303) (not of Guppy).

Chicoreus (Chicoreus) venezuelanus (F. Hodson). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 188, pl. 2, fig. 1.

Holotype: Paleont. Resh. Inst., PRI 24097; height 78.5 mm, diameter 54 mm.

Type locality: Urumaco Formation; Río Codore, 4.65 km north and 500 m west of Urumaco, Edo. de Falcón, Venezuela.

Occurrence: Urumaco Formation, Venezuela; Gatun Formation, Panama; Río Banano Formation, Costa Rica.

Figured specimens: Fig. 3, PRI 24101 (paratype); height 48.5 mm, diameter 30 mm; locality same as holotype. Fig. 4, USNM 450360; height 20.3 mm, diameter 12.0 mm; locality TU 589. Fig. 5, USNM 450361; height 71.6 mm, diameter (including spines) 49.3 mm; locality TU 589. Fig. 10, USNM 450362; height (as is) 24.8 mm, diameter (as is) 23.5 mm; locality TU 959.

Discussion: The Urumaco Formation is now known to be Early Pliocene in age rather than Middle Miocene, as it was considered previously (Vokes, 1965a, p. 189). This correlates with the Gatun Formation of Panama, where we have collected two incomplete specimens (pl. 5, fig. 10) that are also referable to *C. venezuelanus*.

In 1922 Olsson monographed the mollusks of the "Miocene" of Costa Rica. We now know that most of the species he illustrated come from the Middle Pliocene (zone N.20) Río Banano Formation (= "Gatun" of Olsson), but some are from the Pleistocene Moín Formation. One of the "Gatun" species he unfortunately did not

illustrate is the one he cited as "*Murex cornurectus* Guppy." We have not collected any specimens of *Chicoreus cornurectus*, nor of *C. brevifrons*, which Olsson thought was probably identical with *C. cornurectus*, in Costa Rica. However, in the Río Banano Formation we have several specimens of the species that is probably what Olsson had, for it fits his description: "The varices are large and cross the spire whorls in a spiral direction. Between the varices there is generally a single rib-like elevation in the middle of the whorl" (1922, p. 304). These specimens seem to be referable to *C. venezuelanus*, although they differ slightly in being more strongly ornamented. But with no more than the very poor type material of *C. venezuelanus* for comparison, this difference does not seem to be critical.

Chicoreus venezuelanus is closely related to *C. brevifrons* and has a protoconch identical to that species (compare pl. 5, fig. 4, with Radwin and D'Attilio, 1976, text-fig. 15, protoconch of *C. brevifrons)* with two and one-half bulbous whorls. However, it may be readily distinguished by the appressed suture, the smoother surface, and the pattern of the varical spines. As was noted in the original discussion of this species (Vokes, 1965a, p. 189), there is a superficial resemblance to the Red Sea species, *C. virgineus* (Röding, 1798), which is derived from, and grades into, the widespread Indo-Pacific *C. ramosus* (Linné, 1758), type of the genus. The relationship between *C. virgineus* and *C. ramosus* is identical to the relationship between *C. venezuelanus* and *C. brevifrons*.

Chicoreus (Chicoreus) veronica
Vokes, n. sp.
Plate 5, figure 9

Description: Shell with probably seven teleoconch whorls; protoconch unknown. Spiral ornamentation on earliest preserved whorls of five equal cords; gradually smaller cords intercalated; on body whorl and siphonal canal 15 heavy, raised cords; between these, and often on top of them, numerous fine spiral threads, as many as five between some pairs of cords. Axial ornamentation on earliest preserved whorls of nine equal nodes; on approximately fourth teleoconch whorl every third one enlarged, forming a small varix; others remaining as intervarical nodes, generally two between each pair of varices. In addition, numerous axial growth lines crossing spiral threads giving a shagreened texture to entire shell surface. Varices strong raised ridges, aligned from whorl to whorl up the spire; at crossing of spiral cords short open spines produced, corresponding in size to strength of the cord and connected one to the next by a multi-layered flange. Aperture almost circular, no anal notch; inner lip narrow, smooth, appressed along entire length; inner side of outer lip with several small lirae, best developed on anterior half. Siphonal canal short, broad, almost closed but open by a narrow slit; strongly recurved, previous canals diverging as spurs.

Holotype: Museum of Paleontology, University of California, Berkeley, UCMP 38647; height 66.6 mm, diameter 40.8 mm.

Type locality: UCMP S-4153, Agueguexquite Formation; Veronica, Veracruz, Mexico.

Etymology of name: For the type locality, Veronica, Veracruz.

Occurrence: Agueguexquite Formation, Mexico.

Figured specimen: UCMP 38647 (holotype). Additional localities: TU 638, 1046.

Discussion: In the collections of the Museum of Paleontology, University of California, Berkeley, there is a beautiful specimen of a new species that is said to be from "Veronica, Veracruz." We have not succeeded in locating Veronica, but the associated fauna includes specimens of *Haustellum bellegladeensis* (Vokes), identical to those common in the Agueguexquite Formation. I am sure the locality is somewhere in the vicinity of the type locality of the Agueguexquite, about 15 km east of the old bridge at Coatzacoalcos, for all of the other material with numbers similar to this comes from this area. Therefore, even though the exact locality is uncertain, I do not hesitate to make this specimen the holotype of a new species. We also have broken examples of this species from our localities in the Agueguexquite Formation (TU 638, 1046).

This is a puzzling species, which appears to be intermediate between *Chicoreus* s.s. and *Chicoreus (Siratus)*. The fronds are very short and tend to coalesce into a narrow flange. The inner lip, however, is completely smooth, with no trace of rugae such as most species of *Siratus* have and, for this reason, it seems probable that the resemblance to *Siratus* is a result of convergence. This new species most nearly resembles *C.(C.) venezuelanus* and may

prove to be only a northern variant of that form. But, on the basis of the material at hand, *C. veronica* differs in being more strongly ornamented, with a less appressed suture, a less obvious anal notch, and a small flange along the length of the varices rather than any spines.

CHICOREUS (CHICOREUS) sp. cf. C. CLAUSII (Dunker)
Plate 5, figure 2

[?] *Murex clausii* DUNKER, 1879, Jour. de Conchyl., v. 27, p. 215, pl. 8, fig. 6.

Chicoreus (Chicoreus) species cf. *C. (C.) clausii* (Dunker). VOKES, 1989, Bulls. Amer. Paleontology, v. 97, no. 332, p. 36, pl. 6, figs. 2, 3.

Holotype: Berlin Museum; height 64 mm, diameter 36 mm.

Type locality: Tema, Ghana, West Africa (restricted by Vokes, 1989b, p. 37).

Occurrence: Mao Formation, Dominican Republic. Recent, West Africa.

Figured specimen: USNM 365143; height 33.2 mm, diameter 23.9 mm; locality TU 1352.

Discussion: In the Middle Pliocene (zone N.20) Mao Formation of the Dominican Republic we collected three battered examples of a species that as best can be determined is the same as the living West African species *C. clausii* (Dunker). There are several other species related to the West African fauna also present in the fossil record of the Dominican Republic; thus, the find is not totally inexplicable.

CHICOREUS (CHICOREUS) SPECTRUM (Reeve)

Chicoreus (Chicoreus) argo (Clench and Pérez Farfante). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 194.

Chicoreus (Chicoreus) spectrum (Reeve). VOKES, 1974, Tulane Stud. Geol. Paleont., v. 11, no. 2, p. 90, pl. 3, fig. 1 (holotype).

Chicoreus spectrum (Reeve). RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 43, pl. 5, fig. 1; FAIR, 1976, The Murex Book, p. 77, pl. 8, fig. 112 (holotype).

Holotype: Brit. Mus. (Nat. Hist.), BMNH 1950-23-1; height (incomplete) 113 mm, diameter (excluding spines) 49 mm.

Type locality: Grenada, Lesser Antilles (type locality of *Murex imbricatus* Higgins and Marrat, 1877, = *M. argo* Clench and Pérez Farfante, 1945).

Occurrence: Recent only, Lesser Antilles to northern Brazil.

Discussion: Although *C. cornurectus* has been considered to be ancestral to (or even synonymous with) *C. brevifrons,* we now know the two species are essentially coeval and it is *C. spectrum* that is the living representative of the *C. cornurectus* line. The Recent species has a more elongated shell, both in the spire and, especially, in the siphonal canal. Although large specimens of *C. spectrum* are more common than of *C. cornurectus,* one example of the latter from the Dominican Republic, if complete, would measure 150 mm in height (Vokes, 1989b, p. 33) and would exceed the largest specimens of *C. spectrum,* which reach about 120 mm.

Subgenus SIRATUS Jousseaume 1880

Siratus JOUSSEAUME, 1880, Le Naturaliste, Année 2, no. 42, p. 335.

Type species: *Purpura sirat* Adanson, 1757 [= *Murex senegalensis* Gmelin, 1791], by original designation.

Discussion: The origins of the subgenus *Siratus* are uncertain. The Early Oligocene species *C.(S.) stetopus* (de Gregorio) treated below is a likely ancestor for those species similar to the type of the group: *C.(S.) senegalensis.* But, by the Early Miocene the more spinose form also developed, as shown by the several species from Florida and Venezuela. Whether both of these lines were originally derived from the same ancestral type is uncertain and there may be some parallelism involved. Because there is so much intergrading between the two morphotypes – those with spinose varices and those with flanged varices – any attempt to separate the two groups is impossible.

In the original coverage of the species now included in *Siratus,* which as noted above, were considered to be members of *Murex (Murex),* those Recent species with no fossil representation were not treated systematically and the reader was referred to "The genus *Murex* in the western Atlantic" (Clench and Pérez Farfante, 1945). In the interest of a complete study, they will be included herein; however, the "starting point" will be Clench and Pérez Farfante rather than *Cenozoic Muricidae,* Part I.

CHICOREUS (SIRATUS) STETOPUS
(de Gręgorio)
Plate 6, figure 1

Chicoreus (Phyllonotus) stetopus (de Gregorio). VOKES, 1967, Tulane Stud. Geol., v. 5, no. 3, p. 138, pl. 1, figs. 1-5; MACNEIL and DOCKERY, 1984, Mississippi Bur. Geol., Bull. 124, p. 123, pl. 4, fig. 16 only [fig. 17 = *C.(P.) mississippiensis* (Conrad)].

Holotype: Paleont. Resh. Inst., PRI 26431; height (incomplete) 14.5 mm, diameter 10 mm.

Type locality: Unknown, probably Mint Springs Bayou, Vicksburg, Mississippi (= TU 76).

Occurrence: Red Bluff and Mint Springs formations, Mississippi.

Figured specimen: USNM 450364; height 26.8 mm, diameter 13.3 mm; locality TU 1289. Additional localities: TU 226, 642, 1288, 1290.

Discussion: When this species was originally treated (Vokes, 1967b, p. 138) we had no material from the Red Bluff Formation (Early Oligocene). In that formation there are many specimens of a small muricid that appears to be the same as the one I referred to *C. stetopus* from the somewhat younger Mint Springs Formation. The Red Bluff specimens are marked by having a varical flange that is extremely expanded in some specimens (pl. 6, fig. 1). Although this species closely resembles members of the subgenus *Phyllonotus (C. mississippiensis* and *C. dormani,* see below) the varical flange is more characteristic of the subgenus *Siratus*. For this reason, it is appropriate to place the species here, although it may be transitional between the

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PLATE 6

Figures — Page

1. *Chicoreus (Siratus) stetopus* (de Gregorio) (X 2) 38
   USNM 450364; height 26.8 mm, diameter 13.3 mm.
   Locality: TU 1289, Mississippi; Red Bluff Formation.
2. *Chicoreus (Siratus) denegatus* (Jung) (X 1 1/2) 40
   UCMP 38648; height 34.7 mm, diameter 21 mm.
   Locality: UCMP S-8360, Paraguaná Peninsula, Venezuela; Cantaure Formation.
3, 4. *Chicoreus (Siratus) quirosensis* (Hodson) (X 1 1/2) 40
   3. PRI 24104 (holotype); height 32 mm, diameter 16 mm.
      Locality: Quiroz, Venezuela; La Rosa Formation.
   4. USNM 450365; height 28 mm, diameter 16.5 mm.
      Locality: TU 1269, Venezuela; Cantaure Formation.
5, 6. *Chicoreus (Siratus) chipolanus* (Dall) 40
   5. (X 2) USNM 450366; height 29.5 mm, diameter 17 mm.
      Locality: TU 456, Florida; Chipola Formation.
   6. (X 1 1/2) USNM 450367; height 37.9 mm, diameter 22.8 mm.
      Locality: TU 546, Florida; Chipola Formation.
      (Color pattern under ultraviolet light)
7. *Chicoreus (Siratus) juliagardnerae* Vokes (X 1 1/2) 41
   USNM 643750 (holotype); height 37.5 mm, diameter (excluding spines) 16.6 mm.
   Locality: TU 456, Florida; Chipola Formation.
8-11. *Chicoreus (Siratus) sextoni* Vokes, n. sp. 41
   8. (X 1 1/2) USNM 450368 (holotype); height 32 mm, diameter 20.4 mm.
      Locality: TU 951, Florida; Chipola Formation.
   9. (X 1 1/2) USNM 643751; height 28 mm, diameter 11.5 mm.
      Locality: TU 70, Florida; Chipola Formation.
   10. (X 10) USNM 643767; height 20mm, diameter 9 mm.
      Locality: TU 70, Florida; Chipola Formation.
   11. (X 2) Mus. Nacl. Rio de Janeiro DNPM 553; height (as is) 20.5 mm, diameter (as is) 16.8 mm.
      Locality: Rio Pirabas, Pará, Brazil; Pirabas Limestone.
12. *Chicoreus (Siratus) nicholsi* (Gardner) (X 1 1/2) 42
   USNM 450369; height 29.4 mm, diameter 18.8 mm.
   Locality: TU 69A, Florida; Shoal River Formation.

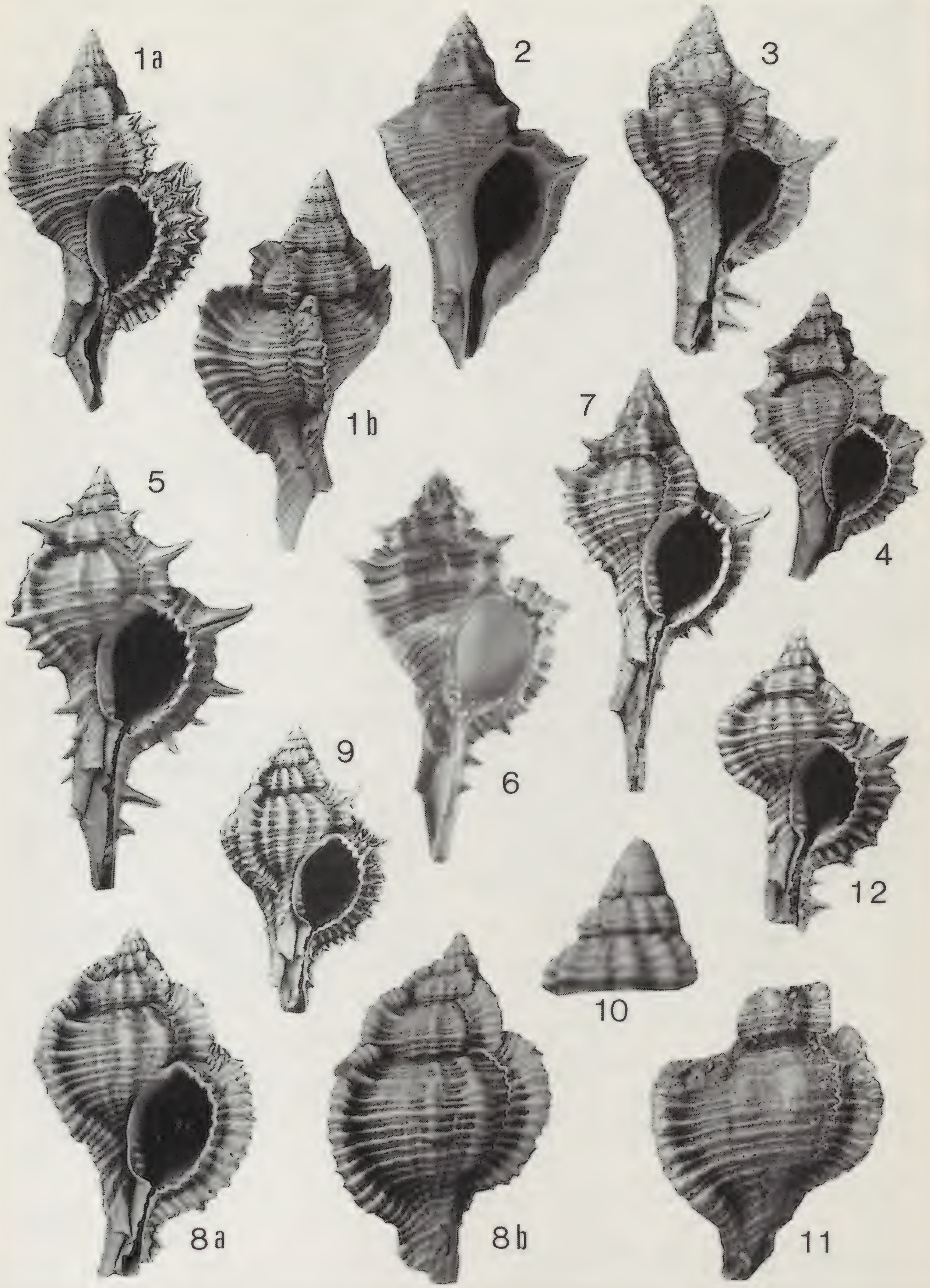

PLATE 6

older *Phyllonotus* group and the younger *Siratus* group.

Chicoreus (Siratus) denegatus (Jung)
Plate 6, figure 2

Murex (Siratus?) triangularis JUNG, 1965, Bulls. Amer. Paleontology, v. 49, no. 223, p. 522, pl. 69, fig. 9, pl. 70, figs. 1, 2.

Murex (Siratus) denegatus JUNG, 1966, Tulane Stud. Geol., v. 4, no. 2, p. 77 (*n.n. pro Murex triangularus* Jung, *non M. triangulus* Brown, 1818, *nec* Risso, 1826, *nec* von Koenen, 1889).

Holotype: Naturhistorisches Museum Basel, NMB H 13711; height 40.1 mm, diameter 24.2 mm.

Type locality: Cantaure Formation; south of Casa Cantaure, Paraguaná Peninsula, Edo. de Falcón, Venezuela (= TU 1269).

Occurrence: Cantaure Formation, Venezuela.

Figured specimen: UCMP 38648; height 34.7 mm, diameter 21 mm; locality UCMP S-8360, same as holotype. Additional localities: TU 1269.

Discussion: When describing this unusual species, Jung (1965, p. 523) stated that "it is doubtful whether this species belongs to the subgenus *Siratus*." His concern is well-founded, for *C. denegatus* is unlike any other species of *Siratus*, with an elongate open aperture and no varical formation until the last two whorls. This latter feature may indicate a closer relationship to the genus *Eupleura* Adams and Adams, 1853. The shell looks not unlike a three-varixed *Eupleura*, but this may only be convergence. In truth, as Jung noted (1965, p. 523), "I have not found any form comparable to this species."

Although common in the Early Miocene beds of the Cantaure Formation, *C. denegatus* has not been found elsewhere.

Chicoreus (Siratus) quirosensis (F. Hodson)
Plate 6, figures 3, 4

Murex (Murex) quirosensis F. Hodson. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 98, pl. 1, fig. 4.

Chicoreus (Siratus) quirosensis (F. Hodson). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 183.

Murex (Murex) recurvirostris quirosensis F. Hodson. JUNG, 1965, Bulls. Amer. Paleontology, v. 49, no. 223, p. 518, pl. 69, fig. 7.

Holotype: Paleont. Resh. Inst., PRI 24104; height 32 mm, diameter 16 mm.

Type locality: La Rosa Formation; Quiros [Quiroz], Disto. de Miranda, Edo. de Zulia, Venezuela.

Occurrence: La Rosa and Cantaure formations, Venezuela.

Figured specimens: Fig. 3, PRI 24104 (holotype). Fig. 4, USNM 450365; height 28 mm, diameter 16.5 mm; locality TU 1269.

Discussion: This species is now known to have come from the La Rosa Formation, which is correlated with the Agua Clara Formation (see *Lexico Estratigrafico de Venezuela,* 1970, p. 345), dated as Early Miocene (Bolli, 1972) rather than Oligocene as originally considered by Hodson. The Quiroz fauna is correlated with the Cantaure fauna of the Paraguaná Peninsula, from whence Jung (1965, pl. 69, fig. 7) has figured an example similar to that figured herein (pl. 6, fig. 4). These specimens differ from the type (pl. 6, fig. 3) in having a second varical spine at the base of the body whorl; however, other specimens from the Cantaure Formation have only a single spine at the shoulder. This variable character is probably what Hodson was referring to when he stated: "Intergrading forms are found in the States of Zulia and Falcon" (*in* Hodson and Hodson, 1931, p. 37).

Chicoreus (Siratus) chipolanus (Dall)
Plate 6, figures 5, 6

Murex (Murex) chipolanus Dall. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 98, pl. 1, fig. 3.

Chicoreus (Siratus) chipolanus (Dall). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 183; VOKES, 1972, Earth Sci., v. 25, no. 3, p. 122, pl. 1, fig. 4.

Lectotype: USNM 112156 (designated by Vokes, 1963a, p. 99); height 38 mm, diameter (excluding spines) 20 mm.

Type locality: USGS 2212, Chipola Formation; Tenmile Creek, "one mile west of Chipola River," Calhoun County, Florida (= TU 546).

Occurrence: Chipola Formation, Florida.

Figured specimens: Fig. 5, USNM 450366; height 29.5 mm, diameter 17 mm; locality TU 456. Fig. 6, USNM 450367; height 37.9 mm, diameter 22.8 mm; locality TU 546. Additional localities: TU 549, 655, 708, 709, 786, 787, 817, 830, 831, 951, 998, 1021, 1051, 1097, 1098.

Discussion: One of the most common muricid species in the Chipola Formation, *C.(S.) chipolanus* is almost totally confined to outcrops along Tenmile Creek. A single

fragment from the Chipola River (TU 549) is the only trace of the species anywhere else.

The color pattern of *C. chipolanus* (as revealed by ultra-violet light, see pl. 6, fig. 6) is similar to many living species of the *Siratus* group, especially *C.(S.) articulatus* (Reeve, 1845), with broad dark bands at the shoulder and base of the body whorl, and dark lines on the raised spiral cords. It appears that this Chipola species with its spinose varices is ancestral to the younger *C.(S.) articulatus*.

Chicoreus (Siratus) juliagardnerae Vokes
Plate 6, figure 7

Murex (Murex) gardnerae VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 99, pl. 1, fig. 1.
Chicoreus (Siratus) gardnerae (Vokes). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 183.
Chicoreus (Siratus) juliagardnerae VOKES, 1970, Tulane Stud. Geol. Paleont., v. 8, no. 1, p. 51 (*n.n. pro Murex gardnerae* Vokes, *non Alectrion gardnerae* Dall, 1915 = *Murex trophoniformis* Heilprin, 1887); VOKES, 1972, Earth Sci., v. 25, no. 3, p. 122, pl. 1, fig. 2.

Holotype: USNM 643750; height 37.5 mm, diameter (excluding spines) 16.6 mm.

Type locality: TU 456, Chipola Formation; Tenmile Creek, about 1/2 mi downstream from bridge of Florida Highway 73 (NE 1/4 Sec. 12, T1N, R10W), Calhoun County, Florida.

Occurrence: Chipola Formation, Florida.

Figured specimen: USNM 643750 (holotype). Additional localities: TU 457, 552, 554, 555, 655, 708, 709, 786, 787, 810, 817, 825, 830, 831, 951, 998, 1021, 1097, 1098.

Discussion: As noted when renaming this secondary homonym (Vokes, 1970c, p. 51), *C.(S.) juliagardnerae* is most common in the outcrops along Tenmile Creek, where it occurs with the similar *C.(S.) chipolanus*. However, *C. juliagardnerae* is more widespread than *C. chipolanus*, as we have several examples from localities along the Chipola River, and one juvenile from Farley Creek (TU 825).

Considering the later species of *Siratus* in the western Atlantic area, it appears that *C.(S.) juliagardnerae*, with its long siphonal canal, is ancestral to the modern species *C.(S.) formosus* (Sowerby).

Chicoreus (Siratus) sextoni Vokes, n. sp.
Plate 6, figures 8-11

[?] *Murex* sp. indet. MAURY, 1925, Serv. Geol. Min. Brasil, Mon. 4, pl. 6, fig. 15.
Murex (Murex) nicholsi Gardner. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 105 [in part, not of Gardner], pl. 3, figs. 4, 5 only.
Chicoreus (Siratus) nicholsi (Gardner). VOKES, 1972, Earth Sci., v. 25, no. 3, p. 122, pl. 1, fig. 3 (not of Gardner).

Description: Shell with seven teleoconch whorls and a protoconch of three and one-half, polished conical whorls, ending at a small recurved varix. Spiral ornamentation on earliest teleoconch whorls of four small cords, increasing in strength and adding intermediary secondary cords up to adult size; body whorl and siphonal canal with about 18 to 20 primary cords and a variable number of secondary cords. Axial ornamentation on earliest teleoconch whorls of about 12 small equal ridges; on fourth teleoconch whorl every fourth ridge strengthened into a small varix, with three intermediate ridges remaining as intervarical nodes; with increasing size adapertural node diminishing or disappearing entirely. Varices, three per whorl, narrow; initially with a small recurved spine at the shoulder but larger specimens with only a series of short open spinelets at crossing of spiral cords; each connected to the next by a thin flange of shell material, somewhat better developed anteriorly. Suture impressed, undulated by axial ornamentation. Aperture oval, inner lip heavy, appressed at posterior end, free-standing at anterior end; with numerous rugae over entire length but stronger on anterior half. Inner side of outer lip with about 10 lirae well within the aperture; one strong nodule at posteriormost part, combining with corresponding strong nodule on inner lip forming anal notch. Margin of outer lip crenulated by small adaperturally directed projections formed by notches corresponding to spiral cords. Siphonal canal relatively short, recurved distally; almost sealed but open by a narrow slit.

Holotype: USNM 450368; height 32 mm, diameter 20.4 mm.

Type locality: TU 951, Chipola Formation; Tenmile Creek, about 1 1/4 mi west of Chipola River (SE 1/4 Sec. 12, T1N, R10W), Calhoun County, Florida.

Etymology of name: In honor of Cecil Sexton, owner of much of the land along the south bank of Tenmile Creek (including locality TU 951, the type locality), who possibly loves Tenmile Creek even more than I do.

Occurrence: Chipola Formation and Oak Grove Sand, Florida; (?)Pirabas Limestone, Pará, Brazil.

Figured specimens: Fig. 8, USNM 450368 (holotype). Fig. 9, USNM 643751; height 28 mm, diameter 11.5 mm; locality TU 70. Fig. 10, USNM 643767; height 20 mm, diameter 9 mm;

locality TU 70. Fig. 11, Mus. Nacl. Rio de Janeiro DNPM 553; height (as is) 20.5 mm, diameter (as is) 16.8 mm; locality, mouth of Rio Pirabas, Pará, Brazil. Additional localities: TU 91, 196, 546, 547, 548, 655, 787, 817, 820, 830, 831, 950, 998, 1050, 1098.

Discussion: When I originally treated the Chipola species of *Siratus* (Vokes, 1963a) we had a few specimens of a species that appeared to be the same as *C.(S.) nicholsi* (Gardner). Since that time, we have collected hundreds of specimens, almost all from the lowest beds of the Chipola Formation on Tenmile Creek (localities TU 566, 830, and 951), which show that the two are different.

This new species occurs together with *C.(S.) chipolanus* and *C.(S.) juliagardnerae* at outcrops along Tenmile Creek, but it is never as common as the other two; at most localities we have but one or two specimens. Exceptions are TU localities 546 and 830, where a tremendous volume of material has been collected. There is one incomplete shell from the Oak Grove Sand (TU 91), which may be referable to this species and Maury figured an external mold from the Pirabas Limestone of Brazil that appears to be the same (compare pl. 6, figs. 8b, and 11).

Although it occurs with two other members of the same subgenus, *C.(S.) sextoni* may be distinguished by the broader shell shape, by having a shorter siphonal canal and only very short varical spines, which normally merge into a flange. It is closely related to the Shoal River *C.(S) nicholsi*, with which I confused it, but the latter has coarser spiral ornamentation and the tendency to three stronger spiral cords that give rise to short spines where they cross the varices. It is probable that *C.(S.) sextoni* is ancestral to the *C.(S.) domingensis* (Sowerby) – *C.(S.) springeri* (Bullis) line.

Chicoreus (Siratus) nicholsi (Gardner)
Plate 6, figure 12

Murex (Murex) nicholsi Gardner. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 105 [in part, not Chipola specimens], pl. 3, fig. 3 only.

Chicoreus (Siratus) nicholsi (Gardner). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 183.

Not *Chicoreus (Siratus) nicholsi* (Gardner). VOKES, 1972, Earth Sci., v. 25, no. 3, p. 122, pl. 1, fig. 3 [= *C.(S.) sextoni* Vokes, n. sp.].

PLATE 7

Figures — Page

1. *Chicoreus (Siratus) amplius* Vokes (X 1) 44
   USNM 323868 (holotype); height 71 mm, diameter 50 mm.
   Locality: TU 1293, Dominican Republic; Gurabo Formation.

2, 3. *Chicoreus (Siratus) miltos* Vokes, n. sp. (X 1 1/2) 44
   2. UCMP 38649 (holotype); height 42 mm, diameter 23.2 mm.
   Locality: UCMP S-4257, Almagres, Veracruz, Mexico; Concepcion Inferior Formation.
   3. UCMP 38650 (paratype); height 35.5 mm, diameter 18.7 mm.
   Locality: UCMP S-207, Almagres, Veracruz, Mexico; Concepcion Inferior Formation.

4. *Chicoreus (Siratus) eumekes* Vokes (X 1 1/2) 45
   USNM 323869 (holotype); height 44.9 mm, diameter 19.8 mm
   Locality: TU 1215, Dominican Republic; Gurabo Formation.

5-7. *Chicoreus (Siratus) habros* Vokes, n. sp. 45
   5. (X 2) USNM 450370 (holotype); height 28.8 mm, diameter 14.4 mm.
   Locality: TU 1046, Mexico; Agueguexquite Formation.
   6. (X 2) USNM 450371 (paratype A); height 28.7 mm, diameter 13.9 mm.
   Locality: TU 1046, Mexico; Agueguexquite Formation.
   7. (X 1 1/2) UCMP 38651 (paratype B); height (as is) 27.5 mm, diameter (as is) 19.6 mm.
   Locality: UCMP S-4153, Veronica, Veracruz, Mexico; Agueguexquite Formation.

8. *Chicoreus (Siratus) consuela* (Verrill) (X 1 1/4) 46
   USNM 450372; height 55.2 mm, diameter 27.9 mm
   Locality: TU 1240, Costa Rica; Moín Formation.

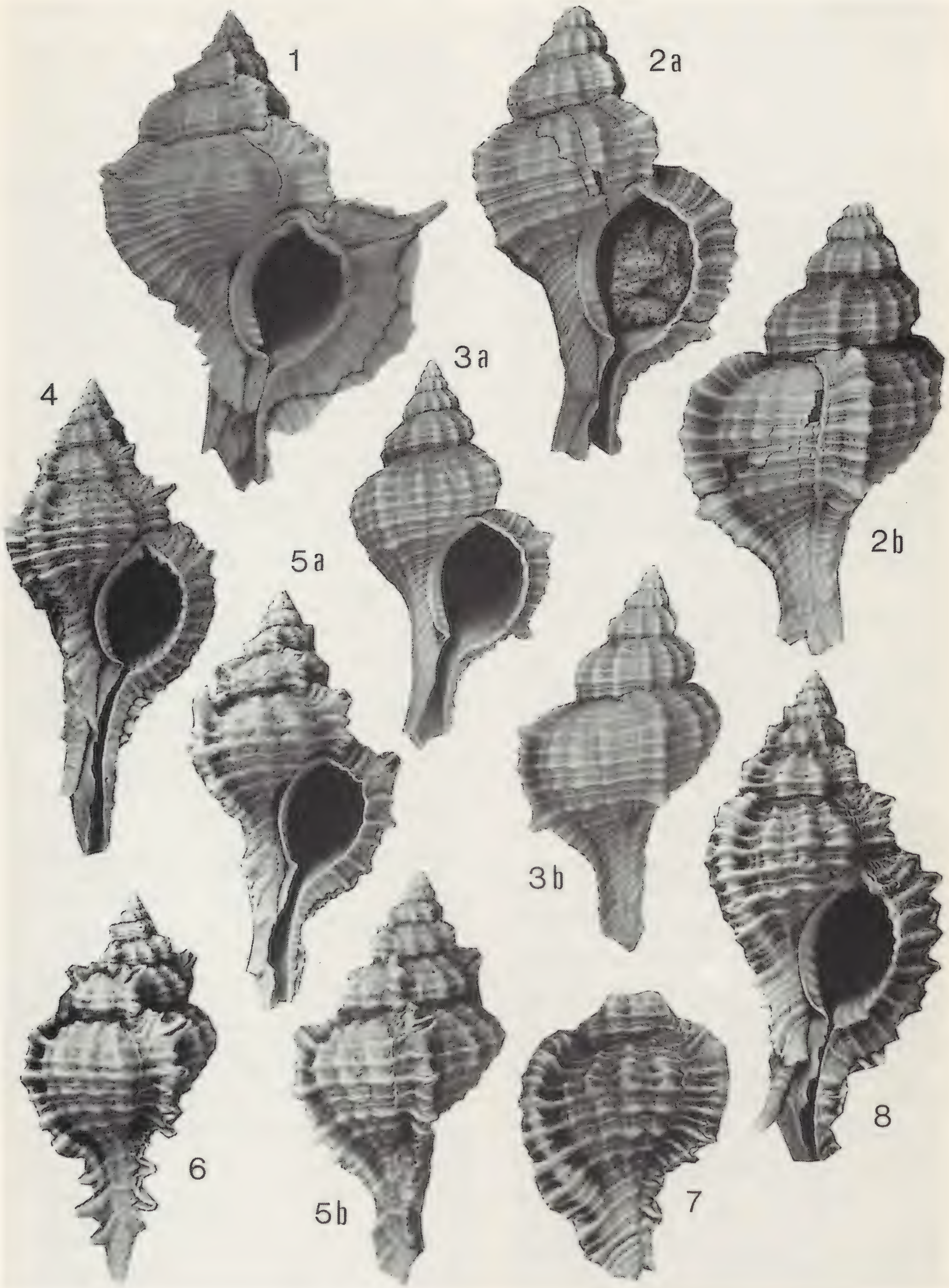

PLATE 7

Holotype: USNM 371851; height 25 mm, diameter 14.5 mm.

Type locality: USGS 3856, Shoal River Formation; 5 to 6 mi west-northwest of Mossyhead, Walton County, Florida.

Occurrence: Shoal River Formation, Florida.

Figured specimen: USNM 450369; height 29.4 mm, diameter 18.8 mm; locality TU 69A.

Discussion: There is not much material available for this species, and that available is poorly preserved. One moderately good juvenile specimen from Shoal River (TU 69A), has a protoconch identical to *C.(S.) sextoni* (three and one-half conical whorls) but is slightly larger in overall size (ca. 0.8 mm *vs.* 0.5 mm in diameter). As shown in the figured specimen (pl. 6, fig. 12), there is a small varical flange, indicating that, as noted previously (Gardner, 1947, p. 519; Vokes, 1963a, p. 106), *C.(S.) nicholsi* is closely related to *C.(S.) domingensis,* but differs from that species in the nature of the protoconch, which in *C.(S.) domingensis* is only one and one-half bulbous whorls.

Chicoreus (Siratus) amplius (Vokes)
Plate 7, figure 1

Murex domingensis Sowerby. MAURY, 1917, Bulls. Amer. Paleontology, v. 5, no. 29, p. 102(266) [in part, not of Sowerby], pl. 16(42), fig. 6 only.

Chicoreus (Siratus) amplius VOKES, 1989, Bulls. Amer. Paleontology, v. 97, no. 332, p. 49, pl. 3, fig. 6.

Holotype: USNM 323868; height 71 mm, diameter 50 mm.

Type locality: TU 1293, Gurabo Formation; Río Mao, west bank, bluff just below Paso Chorrero, or about 12 km (by road) south of Mao, Dominican Republic (= Bluff 1 of Maury, 1917).

Occurrence: Gurabo Formation, Dominican Republic.

Figured specimen: USNM 323868 (holotype). For additional localities in the Dominican Republic, see Vokes, 1989b, p. 50.

Discussion: In the more shallow-water portions of the Gurabo Formation there are rare specimens (five in all) of a large species, most similar to the Recent *C.(S.) tenuivaricosus* (Dautzenberg, 1927), which lives in depths of 15 to 30 meters off the coast of Brazil. This species, *C.(S.) amplius,* unlike any earlier species, is doubtless ancestral to *C.(S.) senegalensis* (Gmelin), type of the subgenus, and *C.(S.) tenuivaricosus.*

Chicoreus (Siratus) miltos Vokes, n. sp.
Plate 7, figures 2, 3

Description: Shell with seven, possibly eight, teleoconch whorls, protoconch of three polished conical whorls, ending at a small varix. Spiral ornamentation on earliest teleoconch whorls of three equal cords, plus one weaker cord on subsutural slope; three major cords continuing and strengthening, weaker cords intercalated; body whorl with five major cords between shoulder and base of body whorl, another one or two weaker major cords on subsutural slope and three or four on siphonal canal; between major cords are weaker secondary cords, each of these flanked by even weaker tertiary threads, until entire surface of shell repeats a pattern of primary, tertiary, secondary, tertiary, primary spiral cords. Axial ornamentation on earliest teleoconch whorls of 10 or 11 equal ridges; on fifth or sixth whorl every fourth ridge strengthened into a small varix with the others remaining as elongate intervarical nodes, usually three between each pair but rarely with a fourth added. Varices rounded, ornamented by raised welts where the spiral cords cross, that at the shoulder and the base of the body whorl somewhat larger and occasionally producing a short spine. Suture incised, undulated by axial ornamentation. Aperture elongate-oval, inner lip narrow, appressed at posterior end, free-standing at anterior end, with numerous rugae over entire length. Inner side of outer lip with about 16 paired lirae. Siphonal canal moderately long, wide, almost closed but open by a narrow slit; recurved at distal end.

Holotype: Museum of Paleontology, University of California, Berkeley, UCMP 38649; height 42 mm, diameter 23.2 mm.

Type locality: UCMP S-4257, Concepcion Inferior Formation; Almagres, Veracruz, Mexico.

Etymology of name: *miltos* (G.) = red earth, a translation of the Spanish *almagres,* which means the same, referring to the type locality.

Occurrence: Concepcion Inferior Formation, Mexico.

Figured specimens: Fig. 2, UCMP 38649 (holotype). Fig. 3, UCMP 38650 (paratype); height 35.5 mm, diameter 18.7 mm; locality UCMP S-207, Almagres, Veracruz, Mexico. Additional localities: UCMP S-4480, S-4483 (both Nueva Teapa, Veracruz), TU 1028, 1514, 1515.

Discussion: In the collections of the Museum of Paleontology, University of California, Berkeley, there are several specimens of an unusual new species here named *C.(S.) miltos.* Almagres, Veracruz, the type locality, is a station on the Trans-Isthmian Railroad, about 25 km southwest of Jaltipan, and is the nearest village to the locality called "Kilometer-70" by Toula

(1911). Although mollusks are no longer preserved at this locality (= TU 1321) Akers (1981, p. 146) found a good Middle Pliocene microfauna. There are three additional specimens from Nueva Teapa, on Mexico Highway 180, about 12 km east of the old bridge at Coatzacoalcos. In the Tulane collections we also have several incomplete specimens from the Nueva Teapa area, all from the Concepcion Inferior Formation. One of these, if complete, would be about 90 mm in height and larger than any specimens in the present collection, the largest of which is 50 mm.

This new species is not like any other I know. It is unique among the species of *Siratus* (or *Chicoreus*) in that the varices do not form until about the sixth post-nuclear whorl, and there are only two varical spines, one at the shoulder and one at the base of the body whorl. Nevertheless, in all other aspects it is a typical *Siratus*.

Chicoreus (Siratus) eumekes Vokes
Plate 7, figure 4

Chicoreus (Siratus) eumekes VOKES, 1989, Bulls. Amer. Paleontology, v. 97, no. 332, p. 51, pl. 3, figs. 11, 12.

Holotype: USNM 323869; height 44.9 mm, diameter 19.8 mm.

Type locality: TU 1215, Gurabo Formation; Río Gurabo, bluffs on both sides, from the ford on the Los Quemados-Sabaneta road upstream to approximately 1 km above the ford, Dominican Republic (= Zone D of Maury, 1917).

Occurrence: Gurabo Formation, Dominican Republic.

Figured specimen: USNM 323869 (holotype). For additional localities in the Dominican Republic, see Vokes, 1989b, p. 52.

Discussion: This species occurs in the coralline facies of the Gurabo Formation, indicating that its nearest relative is the living reef-dweller *C.(S.) consuela* (Verrill).

Chicoreus (Siratus) habros Vokes, n. sp.
Plate 7, figures 5-7

Description: Shell with probably seven teleoconch whorls in the adult, and a protoconch of two and one-half smooth conical whorls, exact termination uncertain. Spiral ornamentation on earliest teleoconch whorls of four equal cords, gradually changing to alternating major and minor cords; body whorl with approximately six major and six minor cords, a few tertiary threadlets intercalated between some pairs; an additional six weaker major and six minor cords on siphonal canal. Axial ornamentation on initial teleoconch whorl of 12 rounded ridges; by third teleoconch whorl every third ridge enlarged to form a varix, with the other two remaining as intervarical ridges; on fourth teleoconch whorl a third intervarical node added between each pair of varices, persisting up to body whorl. Where spiral cords cross varices small open spines produced, that at shoulder slightly larger, all connected by a small flange, best developed on the anterior portion of the whorl and on the siphonal canal. Suture deeply incised, giving a rounded appearance to each whorl. Aperture oval, inner lip narrow, appressed at posterior end, free-standing at anterior end, elongate rugae along entire length. Inner side of outer lip with about nine lirae, anal notch broad and shallow. Siphonal canal long, wide, almost closed but open by a narrow slit; recurved at distal end.

Holotype: USNM 450370; height 28.8 mm, diameter 14.4 mm.

Type locality: TU 1046, Agueguexquite Formation; roadcuts on both sides of Mexico Highway 180, 12 km east of junction with side road into Coatzacoalcos, Veracruz, Mexico. (This is the locality described in Perrilliat Montoya, 1960, p. 5).

Etymology of name: *habros* (G.) = pretty, dainty, graceful.

Occurrence: Agueguexquite Formation, Mexico.

Figured specimens: Fig. 5, USNM 450370 (holotype). Fig. 6, USNM 450371 (paratype A); height 28.7 mm, diameter 13.9 mm; locality TU 1046. Fig. 7, UCMP 38651 (paratype B); height (as is) 27.5 mm, diameter (as is) 19.6 mm; locality UCMP S-4153, Veronica, Veracruz. Additional localities: TU 638, 1347.

Discussion: In the Agueguexquite Formation, to the east of Coatzacoalcos, Veracruz, we have a large number of specimens, almost all of which are fragmentary, of a species most similar to the Dominican *C.(S.) eumekes* Vokes. From the latter it differs in the protoconch with fewer whorls (two and one-half *vs.* three and one-half in *eumekes*), its smaller aperture, more elaborate varical flange, and a surface ornament that appears more "beaded," resulting from the intersection of the stronger spiral cords and smaller intervarical ridges of *C.(S.) habros*. This new species also resembles the later *C.(S.) consuela* but may be distinguished from the latter by its much stronger spiral cords, which result in more produced varical spines, and the more incised suture, which gives the whorls of *C. (S.) habros* a more rounded appearance.

In the collections of the Museum of Paleontology, University of California, Berkeley, from a locality that we have not been able to find (Veronica, Veracruz) there is an incomplete specimen, here figured as paratype B (pl. 7, fig. 7). The fauna at this locality includes *Haustellum bellegladeensis* (Vokes), which as noted above is common in the Agueguexquite Formation, and it is assumed that the beds at Veronica are to be referred to that formation also.

CHICOREUS (SIRATUS) CONSUELA (Verrill)
Plate 7, figure 8

Murex (Murex) pulcher A. Adams. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 96.

Not *Murex (Murex) pulcher* A. Adams. CLENCH, 1959, Johnsonia, v. 3, no. 39, p. 333; RIOS, 1970, Coastal Brazilian Seashells, p. 77, pl. 20 [= *C. (S.) coltrorum* Vokes].

Murex (Murex) consuelae [emend.] Verrill. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 111.

Chicoreus (Siratus) consuelae (Verrill). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 195.

Not *Siratus consuela* (Verrill). RIOS, 1975, Brazilian Marine Moll. Icon., p. 84, pl. 24, fig. 342 [= *C.(S.) coltrorum* Vokes].

Siratus consuela (Verrill). RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 106, pl. 17, fig. 13; FAIR, 1976, The Murex

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PLATE 8

Figures — Page

1. *Chicoreus (Siratus) yaquensis* (Maury) (X 1 1/4) 48
   ANSP 3255A (paralectotype); height 42 mm, diameter 23 mm.
   Locality: (?)TU 1227, Dominican Republic; Gurabo Formation.
2. *Chicoreus (Siratus) ciboney* (Clench and Pérez Farfante) (X 1 1/4) 49
   USNM 450373; height 41.5 mm, diameter 25 mm.
   Locality: USGS 18398, Jacmel, Haiti; unnamed formation.
3-5. *Chicoreus (Siratus) domingensis* (Sowerby) 50
   3. (X 1) USNM 323871; height 55.1 mm, diameter 27.4 mm.
      Locality: TU 1250, Dominican Republic; Gurabo Formation.
   4. (X 1) UCMP 38652; height 53.7 mm, diameter 32.8 mm.
      Locality: UCMP S-4004, Jesus Carranza, Veracruz, Mexico; (?)Medias Aguas Beds.
   5. (X 1 1/4) UCMP 38653; height 42.5 mm, diameter 24.8 mm.
      Locality: UCMP S-2, Bowden, Jamaica; Bowden Formation.
6-8. *Chicoreus (Siratus) formosus* (Sowerby) 50
   6. (X 1) NMB H 16990; height 54.6 mm, diameter 33.7 mm.
      Locality: NMB 15833, Dominican Republic (= TU 1352); Mao Formation.
   7. (X 1 1/2) USNM 369459; height 38.4 mm, diameter 19.8 mm.
      Locality: Bowden, Jamaica; Bowden Formation.
   8. (X 1) USNM 450374; height (as is) 47 mm, diameter (as is) 32 mm.
      Locality: Telfers Island, Panama; Gatun Formation.
9, 10. *Chicoreus (Siratus) articulatus* (Reeve) 51
   9. (X 1 1/2) NMB H 16993; height 35 mm, diameter (excluding spines) 21.6 mm.
      Locality: NMB 15833, Dominican Republic (= TU 1352); Mao Formation.
   10. (X 1 1/4) UCMP 38654; height 40.4 mm, diameter 23.3 mm.
      Locality: UCMP S-2, Bowden, Jamaica; Bowden Formation.
11. *Chicoreus (Siratus) springeri* (Bullis) (X 1 1/4) 52
   USNM 450375; height 46 mm, diameter (excluding spines) 25.7 mm.
   Locality: TU 1240, Costa Rica; Moín Formation.
12. *Chicoreus (Siratus) senegalensis* (Gmelin) (X 1 1/4) 53
   USNM 878009; height 44.4 mm, diameter 27.7 mm.
   Locality: Cabo Frio, Brazil; Recent.
13. *Chicoreus (Siratus) thompsoni* (Bullis) (X 1 1/2) 52
   USNM 878010 (paratype); height 33.7 mm, diameter 16.6 mm.
   Locality: *Oregon* Sta. 2061, off Amazon River, Brazil; Recent.

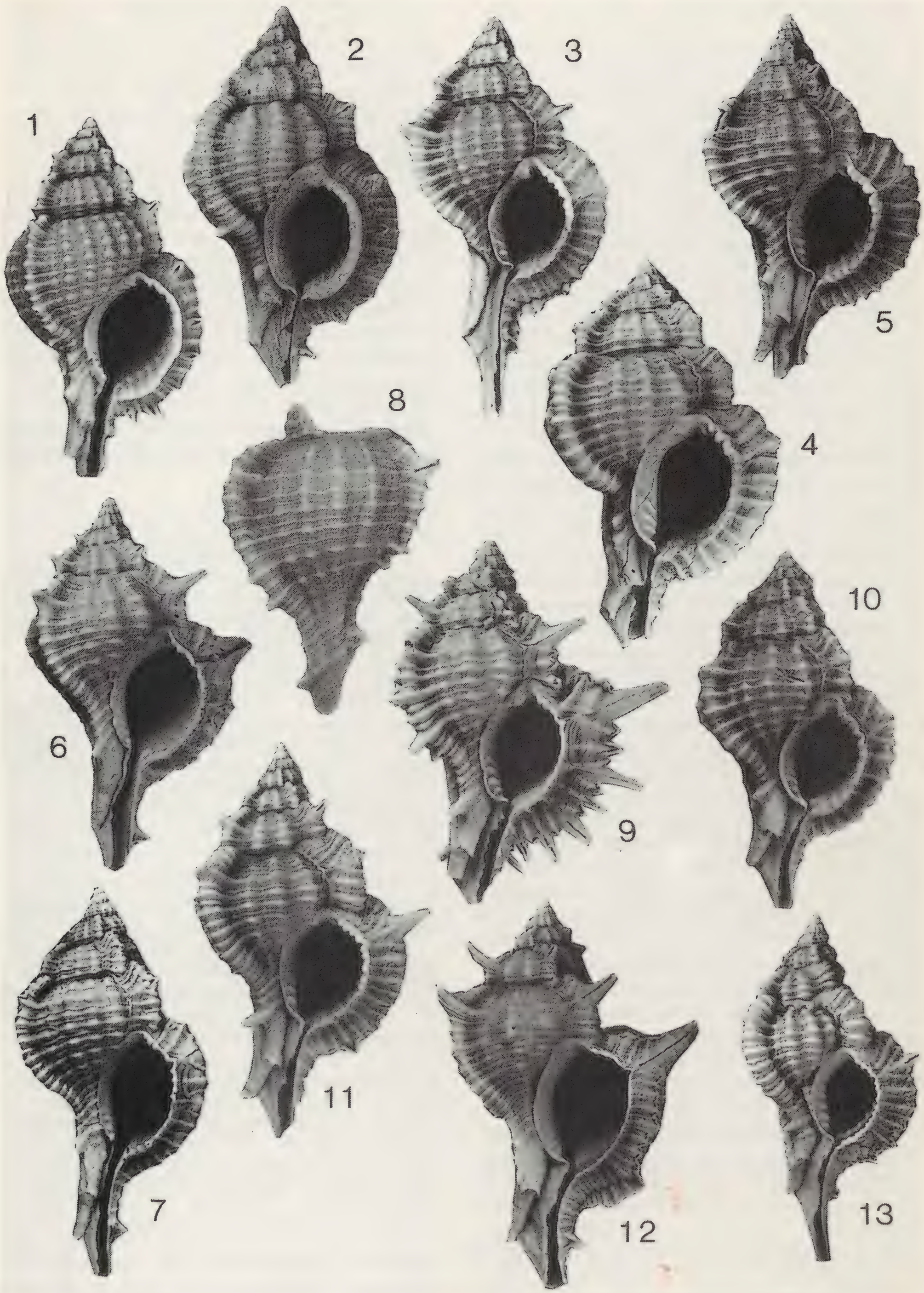

PLATE 8

Book, p. 33, pl. 5, fig. 69.
Not *Murex (Murex) consuelae* (Vokes) [*sic*]. RIOS 1985, Seashells of Brazil, p. 82, pl. 29, fig. 357 [= *C.(S.) coltrorum* Vokes].

Holotype: Not found; height 57-65 mm, diameter 29-34 mm (*fide* Verrill, 1950a, p. 7); Acad. Nat. Sci. Philadelphia, ANSP 209548 (? paratype); height 49.3 mm, diameter 20.4 mm.

Type locality: Off Soufriere, Dominica, Lesser Antilles, 40-50 fms (73-91 m).

Occurrence: Moín Formation, Costa Rica. Recent, Gulf of Mexico and Caribbean Sea.

Figured specimen: USNM 450372; height 55.2 mm, diameter 27.9 mm; locality TU 1240. Additional localities: TU 954, 1239, 1307.

Discussion: The species name *Murex pulcher* A. Adams, 1853, is preoccupied by *M. pulcher* J. Sowerby, 1813, and Defrance, 1827, and has been replaced by the junior synonym originally named as *Murex pulcher* subsp. *consuela* Verrill, 1950. When I first discussed this replacement name (Vokes, 1963a, p. 111), the *Code of Zoological Nomenclature* (ICZN, 1961) mandated an emendation [Art. 31(a)]. However, the Second Edition of the *Code* (ICZN, 1964) reduced this to a recommendation and added [Art. 32(b)] that the original spelling is to be preserved unaltered; therefore, the original orthography must be restored.

This species has been considered to range from the Gulf of Mexico, throughout the Caribbean and beyond, as far south as Espirito Santo, Brazil. However, the specimens south of the Amazon River are a different species, recently named *C.(S.) coltrorum* (Vokes, 1990b, p. 127). Nevertheless, *C.(S.) consuela* is widely distributed in reefal environments, from off the coast of Texas (Flower Garden Banks) to Curaçao (de Jong and Coomans, 1988, p. 71), as well as in the Pleistocene Moín Formation of Costa Rica, where we have numerous specimens from several localities, associated with reefal coral material.

Chicoreus (Siratus) coltrorum Vokes

Murex (Murex) pulcher Adams. CLENCH, 1959, Johnsonia, v. 3, no. 39, p. 333; RIOS, 1970, Coastal Brazilian Seashells, p. 77, pl. 20 (not of Adams).
Siratus consuela (Verrill). RIOS, 1975, Brazilian Marine Moll. Icon., p. 84, pl. 24, fig. 342 (not of Verrill).
Murex (Murex) consuelae (Vokes) [*sic*]. RIOS, 1985, Seashells of Brazil, p. 82, pl. 29, fig. 357 (not of Vokes or Verrill).
Chicoreus (Siratus) coltrorum VOKES, 1990, Nautilus, v. 103, no. 4, p. 127, text-figs. 7-13.

Holotype: Mus. Oceanográfico Rio Grande, MORG 20.749; height 54 mm, diameter 22.4 mm.

Type locality: Ilha de Itaparica, Bahia, Brazil, at low tide.

Occurrence: Recent only, northern Brazil.

Discussion: This species previously has been identified as the Gulf/Caribbean *C.(S.) consuela*. It occurs off the coast of northern Brazil, from Rio Grande do Norte to Espirito Santo, and differs from *C.(S.) consuela* in having a protoconch of only one and one-half whorls; *C.(S.) consuela* has two and one-quarter whorls. In addition, the suture of *C.(S.) coltrorum* is more appressed, causing the individual whorls to appear more rounded and distinct than in *C.(S.) consuela*.

Chicoreus (Siratus) yaquensis (Maury)
Plate 8, figure 1

Murex (Murex) yaquensis Maury. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 107.
Chicoreus (Siratus) yaquensis (Maury). VOKES, 1989, Bulls. Amer. Paleontology, v. 97, no. 332, p. 50, pl. 3, figs. 7-10.

?Synonym:

Murex toreia MAURY, 1925, Serv. Geol. Min. Brasil, Mon. 4, p. 144-145, pl. 6, fig. 11.
Murex cf. *yaquensis* Maury. MAURY, 1925, Serv. Geol. Min. Brasil, Mon. 4, p. 142-143, pl. 6, fig. 12.
Murex (Murex) toreia Maury. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 102, pl. 4, fig. 6 (*ex* Maury, 1925, pl. 6, fig. 11).

Lectotype: Acad. Nat. Sci. Philadelphia, ANSP 3255; height 34.3 mm, diameter 18.4 mm.

Type locality: TU 1227, Gurabo Formation; Arroyo Zalaya, which crosses the road to Jánico from Santiago de los Caballeros, 11 km south of the bridge over the Río Yaque del Norte at Santiago, Dominican Republic (restricted by Vokes, 1989b, p. 50).

Occurrence: Gurabo Formation, Dominican Republic; (?)Pirabas Limestone, Brazil.

Figured specimen: ANSP 3255A (paralectotype); height 42 mm, diameter 23 mm; locality, (?) same as holotype. For additional localities in the Dominican Republic, see Vokes, 1989b, p. 51.

Discussion: When I first treated this species we had no material except for the type lot. Later we collected numerous specimens, all from the deepest water

facies of the Gurabo Formation. Maury (1917, p. 266) thought that *C. yaquensis* might be just a form of *C.(S.) domingensis* (Sowerby), which does occur with *C. yaquensis,* but the two are readily distinguished by the more inflated shell, with distinct beading, present in *C. yaquensis,* and particularly by the totally different protoconch and early whorl development (see Vokes, 1989b, pl. 3, fig. 8).

The unusual nature of the early whorls and the short, stubby siphonal canal demonstrate clearly that *C.(S.) yaquensis* is ancestral to *C.(S.) ciboney* (Clench and Pérez Farfante), which lives today in depths of 350-450 meters – one of the deepest habitats for this deep-water subgenus.

The Brazilian species *Murex toreia* (Maury) is conspecific, based on the material figured by Maury.

Chicoreus (Siratus) ciboney
(Clench and Pérez Farfante)
Plate 8, figure 2

Murex (Murex) ciboney CLENCH and PÉREZ FARFANTE, 1945, Johnsonia, v. 1, no. 17, p. 20, pl. 10, figs. 1-3; VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 96.

Chicoreus (Siratus) ciboney (Clench and Pérez Farfante). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 195.

Siratus ciboney (Clench and Pérez Farfante). RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 105, pl. 17, fig. 12; FAIR, 1976, The Murex Book, p. 30, pl. 5, figs. 61 (holotype), 64 (type of *Murex trilineatus* Reeve).

Synonyms:

Murex trilineatus REEVE, 1845, Conch. Icon., v. 3, *Murex,* pl. 25, fig. 103 (*non Murex trilineatus* J. Sowerby, 1813).

Chicoreus (Siratus) reevei VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 196 (*n.n. pro Murex trilineatus* Reeve *non* Sowerby).

Murex (Murex) yumurinus SARASÚA and ESPINOSA, 1978, Poeyana, no. 179, p. 2, text-figs. 1a-d; SARASÚA and ESPINOSA, 1984, Poeyana, no. 273, p. 2, not text-figs. 1b, 1c [= *C.(S.) cailleti* var. *kugleri* (Clench and Pérez Farfante, 1945)].

Holotype: Harvard Mus. Comp. Zool., MCZ 147315; height 55 mm, diameter 24.6 mm.

Type locality: *Atlantis* Station 3482, off Matanzas, Cuba, 104 meters.

Occurrence: Unnamed formation, Haiti. Recent, Caribbean Sea.

Figured specimen: USNM 450373; height 41.5 mm, diameter 25 mm; locality USGS 18398, north of Jacmel, Arrondissement of Jacmel, Haiti.

Discussion: This deep-water form, which lives in depths from 350 to 450 meters, has not been reported as fossil but in the U.S. National Museum collections there is one specimen collected in southern Haiti by the late W. P. Woodring, at USGS locality 18398 (on the road from Port au Prince to Jacmel, 9 km northwest of the town of Jacmel; the locality actually is "4 miles S.E. of Trouin"). Almost certainly, this is the same as the locality given in Woodring, *et al.* (1924, p. 242) as USGS 9530, where specimens of *C.(S.) articulatus* were collected. In the Dominican Republic report (Vokes, 1989b, p. 47) I discussed this area, which appears identical in depositional history and age to exposures of the Mao Formation along the Río Gurabo (locality TU 1352) where gravel and shells have been washed down-slope into the extremely deep-water beds of the Mao Formation bringing shallow-water species, such as *C.(P.) pomum* (Gmelin), to rest among specimens of deep-water species such as *C. (S.) articulatus* and *C.(S.) formosus.*

Woodring's Haitian specimen (pl. 8, fig. 2) is identical to those taken in fish-traps off Matanzas, Cuba. These rather massive individuals were named *Murex yumurinus* by Sarasúa and Espinosa (1978), due to confusion over the identity of *C.(S.) ciboney.* I can readily sympathize with their problem, also having been misled by the original illustrations into creating an unnecessary synonym for *C.(S.) ciboney.* The shell illustrated by Sarasúa and Espinosa (1984, text-figs. 1B, 1C) as *C.(S.) ciboney* is not that species, but an example of *C.(S.) cailleti* var. *kugleri* (Clench and Pérez Farfante, 1945), misleading Sarasúa and Espinosa into thinking their specimens were a new species.

The original illustrations of *C.(S.) ciboney* are poor; the shells are tilted at a strange angle. No illustration of the apertural side of the holotype was included, but this subsequently was figured by Fair (1976, pl. 5, fig. 61). It should be noted, in passing, that figures 1 and 2 of the original illustrations are a paratype and figure 3 is the holotype, for which the locality is Matanzas as stated in the text, not Punta Alegre as stated in the plate explanation.

Presumably the two localities are switched and the Punta Alegre locality refers to the smaller specimen.

Chicoreus (Siratus) domingensis (Sowerby)
Plate 8, figures 3-5

Murex domingensis Sowerby. MAURY, 1917, Bulls. Amer. Paleontology, v. 5, no. 29, p. 101(265) [in part], pl. 16(42), figs. 3, 4 only [fig. 5 = *Haustellum pennae* (Maury), fig. 6 = *Chicoreus (Siratus) amplius* Vokes].

Not *Murex domingensis* Sowerby. ANDERSON, 1929, California Acad. Sci., Proc., (Ser. 4) v. 18, no. 4, p. 137 [= unnamed species of *Chicoreus*].

Murex (Murex) domingensis Sowerby. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 106, pl. 2, figs. 8, 9 only [fig. 6 = *Haustellum messorius* (Sowerby), fig. 7 = *Haustellum pennae* (Maury)].

Chicoreus (Siratus) domingensis (Sowerby). VOKES, 1989, Bulls. Amer. Paleontology, v. 97, no. 332, p. 43, pl. 4, figs. 1-10, text-fig. 19 (lectotype).

Lectotype: Brit. Mus. (Nat. Hist.), BMNH G. 83 948 (designated by Pflug, 1961, p. 45); height 44.6 mm, diameter 27 mm.

Type locality: TU 1293, Gurabo Formation; Río Mao, west bank, bluff just below Paso Chorrero, or about 12 km (by road) south of Mao, Dominican Republic (= Bluff 1 of Maury, 1917) (restricted by Vokes, 1989b, p. 44).

Occurrence: Gurabo Formation, Dominican Republic; (?)Medias Aguas Beds, Veracruz, Mexico; Punta Gavilan Formation, Venezuela; Bowden Formation, Jamaica.

Figured specimens: Fig. 3, USNM 323871; height 55.1 mm, diameter 27.4 mm; locality TU 1250. Fig. 4, UCMP 38652; height 53.7 mm, diameter 32.8 mm; locality UCMP S-4004, Río Coatzacoalcos, near Jesus Carranza, Veracruz, Mexico. Fig. 5, UCMP 38653; height 42.5 mm, diameter 24.8 mm; locality UCMP S-2, Bowden, Jamaica. For additional localities in the Dominican Republic, see Vokes, 1989b, p. 46.

Discussion: Chicoreus (Siratus) domingensis was covered extensively in the Dominican Republic report and it was noted therein (Vokes, 1989b, p. 45) that the type lot of this species in the British Museum (Natural History) collections includes 22 specimens. Of these, in addition to the lectotype, only three are referable to *C. domingensis*. Nine are *Haustellum messorius* (Sowerby), eight are *Haustellum pennae* (Maury), and one is *C. (S.) amplius* Vokes. That subsequent workers have had problems with the identification of the species is understandable.

In the Dominican Republic *C. domingensis* is confined to the relatively deep-water deposits of the Gurabo Formation. Rare specimens occur in other localities outside the Dominican Republic, however. Rutsch (1934, pl. 4, fig. 2) illustrated a beautiful example from the Punta Gavilan Formation of Venezuela and another specimen from an unknown formation (probably the Late Miocene Medias Aguas Beds) of Veracruz, Mexico is figured here (pl. 8, fig. 4). The species also occurs in the Bowden Formation, Jamaica, together with *C.(S.) articulatus* (Reeve) and specimens that are very similar to *C.(S.) formosus* (Sowerby) (compare pl. 8, figs. 5, 7, and 10). In the Dominican Republic report I considered that *C.(S.) domingensis* was probably ancestral to *C.(S.) formosus* and suggested that the most accurate citation for the Bowden specimens would be as "*C.(S.) domingensis/formosus*." However, work on this paper has convinced me that the real descendant of *C.(S.) domingensis* is *C.(S.) springeri* (Bullis) and that *C.(S.) formosus* represents a parallel line descended from the Chipola species, *C.(S.) juliagardnerae*. Thus, it is entirely possible to have the lineal descendants of the three Chipola species (*C. chipolanus, C. juliagardnerae, C. sextoni*) all occurring together in the Bowden beds (*C. articulatus, C. formosus, C. domingensis*), as they do in the Chipola Formation.

Chicoreus (Siratus) formosus (Sowerby)
Plate 8, figures 6-8

Murex formosus SOWERBY, 1841, Conch. Illus., pl. 197, fig. 112; SOWERBY, 1841, Zool. Soc. London, Proc., pt. 8 (1840), p. 139.

Murex (Murex) antillarum Hinds. CLENCH and PÉREZ FARFANTE, 1945, Johnsonia, v. 1, no. 17, p. 12 [in part, not of Hinds], pl. 6; VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 107 [in part, not of Hinds], pl. 3, figs. 2, 3.

Chicoreus (Siratus) antillarum (Hinds). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 196.

Siratus formosus (Sowerby). RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 106, pl. 17, fig. 9; FAIR, 1976, The Murex Book, p. 43, pl. 5, fig. 56.

Chicoreus (Siratus) formosus (Sowerby). VOKES, 1980, Of Sea and Shore, v. 11, p. 91, text-figs. 1, 2; VOKES, 1989, Bulls. Amer. Paleontology, v. 97, no. 332, p. 47, pl. 4, figs. 14-16.

"Type figure": Sowerby, 1841a, pl. 197, fig. 112 (designated by Vokes, 1989b, p. 48); height 79.8 mm, diameter 26.6 mm (*fide* Sowerby, 1841b, p. 139, as "Long. 3.15; lat. ex. var. 1.05 poll.").

Type locality: Puerto Plata, Dominican Republic (restricted by Vokes, 1989b, p. 48).

Occurrence: Mao Formation, Dominican Republic; Gatun Formation, Panama; Bowden Formation, Jamaica. Recent, Caribbean Sea.

Figured specimens: Fig. 6, NMB H 16990; height 54.6 mm, diameter 33.7 mm; locality NMB 15833 (= TU 1352). Fig. 7, USNM 369459; height 38.4 mm, diameter 19.8 mm; locality, Bowden, Jamaica. Fig. 8, USNM 450374; height (as is) 47 mm, diameter (as is) 32 mm; locality, Telfers Island, Panama.

Discussion: There is a strong similarity between *C. domingensis* and *C. formosus* but in the latter species the shell is larger, more coarsely ornamented, and the siphonal canal is considerably longer. Originally, I thought that there was a direct connection between the two species but, now I believe that three parallel lines of evolution led to three similar appearing species. As noted above, in the basal Pleistocene Bowden Formation of Jamaica, specimens that can be referred to *C. domingensis* (pl. 8, fig. 5) occur with those more like *C. formosus* (pl. 8, fig. 7; this specimen is one of two figured by Woodring, 1928, pl. 17, fig. 7, as *Murex recurvirostris* Broderip). Occurring with these is a representative of the third line, *C.(S.) articulatus* (Reeve) (pl. 8, fig. 10).

Although *C.(S.) formosus* and *C.(S) articulatus* live today in the same general area, they do not occur together; *C.(S.) formosus* lives in slightly shallower water, from 20 to 100 meters and *C. (S.) articulatus* lives from about 100 to 200 meters (Kevan Sunderland, personal communication). In the Dominican Republic the two species are found together at one unusual locality (TU 1352), where extremely shallow water species have been washed downslope into very deep water. Here we have 15 specimens of *C.(S.) formosus* together with more than 100 examples of *C.(S.) articulatus*, indicating that the more shallow living specimens of *C.(S.) formosus* were among the material transported into the deep water habitat of *C.(S.) articulatus*. This is the same type of mixed environment that is found at Bowden, explaining the presence of the three different species together.

Chicoreus (Siratus) articulatus (Reeve)
Plate 8, figures 9, 10

Murex articulatus REEVE, 1845, Conch. Icon., v. 3, *Murex*, expl. to pl. 22 (for *Murex motacilla* var., Sowerby, 1841a, pl. 189, fig. 69).

Murex (Murex) recurvirostris recurvirostris Broderip. PERRILLIAT, 1972, Paleontología Mexicana, no. 32, p. 79, pl. 39, figs. 5-8 (not of Broderip).

Siratus articulatus (Reeve). RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 104, pl. 17, figs. 2, 3; FAIR, 1976, The Murex Book, p. 22, pl. 5, fig. 58.

Chicoreus (Siratus) articulatus (Reeve). VOKES, 1980, Of Sea and Shore, v. 11, p. 91, text-figs. 3-5; VOKES, 1989, Bulls. Amer. Paleontology, v. 97, no. 332, p. 46, pl. 4, figs. 11-13.

Synonyms:

[?] *Murex antillarum* HINDS, 1844, Zool. Soc. London, Proc., pt. 11 (1843), p. 126 [a *nomen dubium;* probably not *M. antillarum* of authors, which = *C.(S.) formosus* Sowerby].

Murex nodatus REEVE, 1845, Conch. Icon., v. 3, *Murex*, pl. 25, fig. 107 (*non M. nodatus* Gmelin, 1791).

Murex gundlachi DUNKER, 1883, Malak. Blatter, (N.S.) v. 6, p. 35, pl. 1, figs. 1, 2.

Murex finlayi CLENCH, 1955, Harvard Mus. Comp. Zool., Brevoria, no. 44, p. 1, text-figs. 1-3; CLENCH, 1959, Johnsonia, v. 3, no. 39, p. 31, pl. 174, figs. 1-3.

Murex woodringi Clench and Pérez Farfante. MORRIS, 1973, Field Guide to Shells, Atlantic and Gulf Coasts and West Indies, Third Ed., p. 193, pl. 52, fig. 6 (not of Clench and Pérez Farfante).

"Type figure": Sowerby, 1841a, pl. 189, fig. 69 (designated by Vokes, 1989b, p. 46); height 50 mm, diameter 25 mm (*fide* Sowerby, 1841a).

Type locality: Off Ocho Rios, Jamaica (restricted by Vokes, 1989b, p. 46).

Occurrence: Mao Formation, Dominican Republic; (?)Medias Aguas Beds, Veracruz, Mexico; unnamed formation, Haiti; Bowden Formation, Jamaica. Recent, Caribbean Sea.

Figured specimens: Fig. 9, NMB H 16993; height 35 mm, diameter (excluding spines) 21.6 mm; locality NMB 15833 (= TU 1352). Fig. 10, UCMP 38654; height 40.4 mm, diameter 23.3 mm; locality UCMP S-2, Bowden, Jamaica. For additional localities in the Dominican Republic, see Vokes, 1989b, p. 47.

Discussion: The problems of identification of *C.(S.) articulatus* and the similar

C.(S.) formosus were discussed at length in an earlier paper (Vokes, 1980) and it was concluded that the best way to distinguish *C. articulatus* from *C. formosus* is by the greater angle of deflection of the siphonal canal in *C. articulatus*. In addition, the color pattern is different; *C. formosus* is monochromatic tan or brown and *C. articulatus* is striped with brown and white bands and also has reddish-brown spiral threads. Both species were figured in Vokes (1980) demonstrating the differences.

More than 100 specimens of this species were collected from one unusual locality (TU 1352) in the Mao Formation in the Dominican Republic. Here, the water depth was probably similar to the habitat of living *C.(S.) articulatus*, as noted above, 100 to 200 meters. The species also occurs at a locality in southern Haiti, near the town of Jacmel, similar in facies to the Mao occurrences (see Vokes, 1989b, p. 47). In addition, we have one specimen from the Bowden Formation, Jamaica (pl. 8, fig. 10), in another deep-water deposit.

Perrilliat (1972, pl. 39, figs. 5-8) figured two specimens from beds at Santa Rosa, Veracruz, Mexico that may be referable to this species. The smaller of the two (USNM 287313 – her pl. 39, figs. 5, 6) is almost certainly the same; the larger (USNM 350018 – her pl. 39, figs. 7, 8) is a battered shell, lacking the diagnostic siphonal canal, but appears to be the same as the smaller one. The aperture is relatively small, with only a shallow anal notch and reduced rugae. This type of aperture is matched by many Recent specimens of this variable species but it does not closely resemble the examples figured here from the Mao and Bowden formations. The age of the beds at Santa Rosa is uncertain. We have been unable to find this remarkable locality but, as noted in the Dominican Republic report (Vokes, 1989b, p. 47), beds in the near vicinity have been dated by Dr. Akers as Late Miocene (N.17) and are here referred to the unit informally named the Medias Aguas Beds by Akers (1980, p. 497). There are no muricids in common with the younger (N.20) Agueguexquite Formation to which these beds were referred by Perrilliat.

Chicoreus (Siratus) springeri (Bullis)
Plate 8, figure 11

Murex (Siratus) springeri BULLIS, 1964, Tulane Stud. Zoology, v. 11, no. 4, p. 104, text-figs. 7, 8.

Chicoreus (Siratus) springeri (Bullis). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 197.

Siratus senegalensis (Gmelin). RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 107 [in part, not of Gmelin], pl. 17, fig. 1 only.

Siratus springeri (Bullis). FAIR, 1976, The Murex Book, p. 78, pl. 6, fig. 70 (holotype); PETUCH, 1987, New Caribbean Moll. Faunas, p. 87, pl. 18, fig. 6 (holotype).

Holotype: USNM 635148; height 70 mm, diameter 32.7 mm.

Type locality: *Oregon* Station 2289, 95 mi north-northeast of Surinam [Suriname] River entrance, Suriname, 75-80 fms (147-146 m).

Occurrence: Moín Formation, Costa Rica. Recent, northern South America.

Figured specimen: USNM 450375; height 46 mm, diameter (excluding spines) 25.7 mm; locality TU 1240.

Discussion: Although not reported previously as fossil, we have many specimens of *C.(S.) springeri* from the Pleistocene Moín Formation, Costa Rica (all from locality TU 1240). These specimens strongly resemble *C.(S.) domingensis* (Sowerby), and differ only in the less appressed suture, the varices being deeply excavated on the abapertural side, and the stronger shoulder spine. Thus, *C.(S.) springeri*, with its relatively short siphonal canal, is more likely the true descendant of *C.(S.) domingensis* than species with extremely long siphonal canals, such as *C.(S.) formosus* (Sowerby) as previously treated in the Dominican report.

Radwin and D'Attilio (1976, p. 108) considered this species a "more coarsely sculptured form" of *C.(S.) senegalensis* (Gmelin), but the resemblance seems to be only of subgeneric importance (compare pl. 8, figs. 11 and 12). The type specimen of *C.(S.) springeri* is a somewhat "atypical" gerontic individual 70 mm in height. Most examples (including several paratypes) are less than 60 mm and resemble the shell figured by Radwin and D'Attilio (1976, pl. 17, fig. 1).

Chicoreus (Siratus) thompsoni (Bullis)
Plate 8, figure 13

Murex (Murex) thompsoni BULLIS, 1964, Tulane Stud. Zoology, v. 11, no. 4, p. 103, text-figs. 3, 4.

Chicoreus (Siratus) thompsoni (Bullis). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 197.

Siratus thompsoni (Bullis). FAIR, 1976, The Murex Book, p. 81, pl. 5, fig. 67 (holotype); PETUCH, 1987, New Caribbean Moll. Faunas, p. 89, pl. 20, fig. 3 (holotype).

Siratus briskasii (Verrill). PETUCH, 1987, New Caribbean Moll. Faunas, p. 89, pl. 18, figs. 5, 6, pl. 21, fig. 13 (not of Verrill).

Holotype: USNM 635147; height 35.8 mm, diameter 18.9 mm.

Type locality: *Oregon* Station 2321, 75 mi north-northeast of Pte. Mana, French Guiana, 34 fms (62 m).

Occurrence: Recent only, northern South America.

Figured specimen: USNM 878010 (paratype); height 33.7 mm, diameter 16.6 mm; locality, *Oregon* Sta. 2061, off mouth of Amazon River, 55-60 fms (100-110 m). (paratype for range extention)

Discussion: Abbott (1974, p. 172) rejected this species as a specimen of *Murex woodringi* "in which the siphonal canal has been broken off and then repaired" and Radwin and D'Attilio (1976) completely overlooked it. Nevertheless, it is a valid form that is another descendant of the *C.(S.) domingensis* line. It differs from the ancestral species in having a narrower shell, with only two or three intervarical nodes in contrast to the three or four in the older form, but in many ways it is closer to *C.(S.) domingensis* than to *C.(S.) springeri,* which comes from the same area.

Bullis (1964, p. 103) observed that the holotype was "somewhat more exotic" than the remainder of the type lot, which generally have a more slender and elongate shell, without spines (see pl. 8, fig. 13). Perhaps this is what caused Petuch (1987, p. 89) to think he had rediscovered the "lost species" *C.(S.) briskasii* (Verrill).The latter is probably a synonym of *C.(S.) motacilla* (Gmelin) but Petuch's figured specimens (1987, pl. 18, figs. 5, 6; pl. 21, fig. 13) are typical examples of *C.(S.) thompsoni.* This serves to extend the range of the species to Venezuela.

Chicoreus (Siratus) beauii (Fischer and Bernardi)

Murex (Murex) beauii Fischer and Bernardi. CLENCH and PÉREZ FARFANTE, 1945, Johnsonia, v. 1, no. 17, p. 14, pl. 7, figs. 1, 2.

Murex (Siratus) beauii Fischer and Bernardi. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 111; BAYER, 1971, Bull. Mar. Sci., v. 21, no. 1, p. 155, text-fig. 27.

Siratus beauii (Fischer and Bernardi). RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 104, pl. 17, fig. 8; FAIR, 1976, The Murex Book, p. 24, pl. 5, fig. 55.

Synonyms:

Murex percoides LOEBBECKE, 1879, Deutsch. Malak. Gesell., Jahr., v. 7, p. 79, pl. 3, fig. 1.

Murex (Murex) branchi CLENCH, 1953, Johnsonia, v. 2, no. 32, p. 360, pl. 179.

Holotype: In the collections of the Journal de Conchyliologie (*fide* Clench and Pérez Farfante, 1945, p. 15); height 120 mm, diameter (including spines) 51 mm.

Type locality: Island of Marie Galente, French West Indies.

Occurrence: Post-Pleistocene, Louisiana. Recent, western Atlantic from Florida to Uruguay.

Discussion: Probably the best known and most unmistakable member of *Siratus,* this species is common in deeper water (173-463 meters, Clench and Pérez Farfante, 1945, p. 15; 201-366 meters, Bullis, 1964, p. 104; 115-275 meters, Bayer, 1971, p. 157; 170-235 meters, Radwin and D'Attilio, 1976, p. 105). Therefore, the several examples collected in relatively shallow water material from "Mud-lump 90" at the mouth of the Mississsippi River (TU 977) were unexpected. According to Morgan *et al.* (1963, p. 41) this material was deposited in depths of approximately 60 meters. These specimens, dated at about 15,000 YBP, are the only reported fossil occurrence of the species.

The variation in varical webbing in this species was noted by Bullis (1964, p. 104), who observed that contrary to popular belief neither depth nor bottom type had any effect on the presence of elaborate webbing. This was dramatically demonstrated by Bayer (1971, text-fig. 27), who figured two extreme examples from the same dredge haul.

Chicoreus (Siratus) senegalensis (Gmelin)
Plate 8, figure 12

Murex (Siratus) senegalensis Gmelin. CLENCH and PÉREZ FARFANTE, 1945, Johnsonia, v. 1, no. 17, p. 24, pl. 13, figs. 1, 2.

Chicoreus (Siratus) senegalensis (Gmelin). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4,

p. 195; VOKES, 1968, Tulane Stud. Geol., v. 6, no. 1, p. 39, text-fig. 2.

Siratus senegalensis (Gmelin). RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 107, pl. 7, fig. 7 only [fig. 1 = *C.(S.) springeri* (Bullis)]; FAIR, 1976, The Murex Book, p. 76, pl. 5, fig. 65.

Holotype: Museum de Hist. Nat. National, Paris; height 58 mm, diameter 34 mm (*fide* Fischer-Piette, 1942, p. 222, pl. 6, fig. 8 – "Le Sirat" Adanson, on which Gmelin's species is based).

Type locality: "Senegal."

Occurrence: Recent only, Brazil.

Figured specimen: USNM 878009; height 44.4 mm, diameter 27.7 mm; locality, Cabo Frio, State of Rio de Janiero, Brazil, 5 meters.

Discussion: Although the type species of the subgenus, *C.(S.) senegalensis* is a most unusual species of *Siratus*, in that it is the only shallow-water Recent form. It is relatively common along the coast of Brazil, ranging from Espirito Santo to Santa Catarina (Rios, 1985, p. 84). How Adanson (1757, p. 125, pl. 8, fig. 19) got the type specimen of "Le Sirat," upon which this species is based, from Senegal remains a mystery to this day. His specimen has been figured by Fischer-Piette (1942, pl. 6, fig. 8) and there is no question about its identity.

Chicoreus (Siratus) tenuivaricosus (Dautzenberg)

Murex calcar KIENER, 1843, Coquilles Vivantes, v. 7, p. 107, pl. 36, fig. 2 (*non Murex calcar* J. de C. Sowerby, 1823, *nec* Scacchi, 1835).

Murex tenuivaricosus DAUTZENBERG, 1927, Res. Camp. Sci. Prince de Monaco, fasc. 72, p. 94 (*n.n. pro Murex calcar* Kiener *non* Sowerby); VOKES, 1969, Tulane Stud. Geol. Paleont., v. 7, no. 2, p. 84.

Chicoreus (Siratus) carioca VOKES, 1968, Tulane Stud. Geol., v. 6, no. 1, p. 39, text-fig. 1 (*n.n. pro Murex calcar* Kiener *non* Sowerby).

Siratus tenuivaricosus (Dautzenberg). RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 108, pl. 17, fig. 16; FAIR, 1976, The Murex Book, p. 80, pl. 5, fig. 57.

Holotype (*Murex calcar* Kiener): Museum de Hist. Nat. National, Paris; height 57 mm (*fide* Fischer-Piette and Beigbeder, 1943, p. 206).

Type locality: Unknown.

Occurrence: Recent only, Brazil.

Discussion: An endemic Brazilian species, *C.(S.) tenuivaricosus* is similar to the shallow-water *C.(S.) senegalensis*. The two forms were compared and figured earlier (Vokes, 1968a), at which time a new name for the preoccupied *Murex calcar* Kiener was proposed. Shortly thereafter the older name *Murex tenuivaricosus* was discovered (Vokes, 1969) and since that time the latter name has become established in the literature. According to Rios (1985, p. 84), this species has the same geographic range (Espirito Santo to Santa Catarina) as the shallow water *C.(S.) senegalensis*, but in depths of 30 to 60 meters (Rios, 1975, p. 85).

Chicoreus (Siratus) motacilla (Gmelin)

Murex (Murex) motacilla Gmelin. CLENCH and PÉREZ FARFANTE, 1945, Johnsonia, v. 1, no. 17, p. 21, pl. 11; VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 96 (as *motacillus*).

Chicoreus (Siratus) motacillus [*sic*] (Gmelin). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 195.

Siratus motacilla (Gmelin). RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 106, pl. 17, fig. 14; FAIR, 1976, The Murex Book, p. 60, pl. 5, fig. 63.

? Synonym:

Murex briskasii VERRILL, 1953, Mins. Conch. Club So. California, no. 128, p. 2, text-figure.

Not *Siratus briskasii* (Verrill). PETUCH, 1987, New Caribbean Moll. Faunas, p. 89, pl. 18, figs. 5, 6, pl. 21, fig. 13 [= *C.(S.) thompsoni* (Bullis)].

"Type figure": Chemnitz, 1788, Conchylien-Cab., v. 10, pl. 163, fig. 1563 (designated by Clench and Pérez Farfante, 1945, p. 22).

Type locality: Barbados, Lesser Antilles (designated by Clench and Pérez Farfante, 1945, p. 22).

Occurrence: Recent only, Lesser Antilles.

Discussion: A well-known species, this form has never been confused with any other. It appears to be confined to the Lesser Antilles; Radwin and D'Attilio (1976, p. 107) record it from Dominica to Barbados. In earlier papers I incorrectly "latinized" the name, which is a noun, *motacilla* – the yellow wag-tail (a bird) – and does not take a masculine termination to agree with the genus.

There are four closely related species living in deeper waters of the Caribbean that are much alike in having the siphonal canal extremely deflected, more so than the other species assigned to this subgenus. These four, *C.(S.) motacilla, C.(S.) cailleti, C.(S.) perelegans*, and *C.(S.)*

aguayoi, differ from each other in the nature of the varical ornamentation, ranging from none in *C. perelegans* to extremely long in *C. aguayoi*, and the number of intervarical nodes, with two in *C. motacilla* and *C. perelegans*, two to four in *C. cailleti* and four in *C. aguayoi*.

The species *Murex briskasii* Verrill, 1953, has never been recognized and the holotype cannot be located. In the collections of the Academy of Natural Sciences, Philadelphia, there is a specimen (ANSP 241569) labeled *Murex briskasii*, from the type locality (Dominica, B.W.I., 100 fms), which is simply a dark colored example of *C.(S.) cailleti*. But the original illustration given by Verrill looks more like a specimen of *C.(S.) motacilla*, with short spines at the shoulder and base of the siphonal canal and a lower spire than is typical in *C. (S.) cailleti*. I suspect the Philadelphia specimen is simply a misidentification by a subsequent collector.

Chicoreus (Siratus) cailleti (Petit de la Saussaye)

Murex (Murex) cailleti Petit de la Saussaye. CLENCH and PÉREZ FARFANTE, 1945, Johnsonia, v. 1, no. 17, p. 17 [in part, not references to *Murex elegans* Beck = *C.(S.) perelegans* Vokes or *Murex trilineatus* Reeve = *C. (S.) ciboney* (Clench and Pérez Farfante)], pl. 9, figs. 3, 4 only [figs. 5, 6 = *C.(S.) perelegans* Vokes); VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 96.

Chicoreus (Siratus) cailleti (Petit de la Saussaye). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 195.

Siratus cailleti (Petit de la Saussaye). RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 105, pl. 17, figs. 4-6; FAIR, 1976, The Murex Book, p. 28, pl. 5, figs. 62, 66 (as *S. perelegans* Vokes).

Synonym:

Murex (Murex) cailleti var. *kugleri* CLENCH and PÉREZ FARFANTE, 1945, Johnsonia, v. 1, no. 17, p. 19, pl. 9, figs. 1, 2; VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 96; VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 195.

Holotype: In the collections of the Journal de Conchyliologie (*fide* Clench and Pérez Farfante, 1945, p. 19); height 60 mm.

Type locality: Guadeloupe, French West Indies.

Occurrence: Recent only, Florida to Barbados.

Discussion: This species was rather badly treated by Clench and Pérez Farfante (1945, p. 17), who included in the synonymy two species that do not belong and separated as a "variety" a form that is synonymous. They give a wide range of depths from 46 to 366 meters; the species is commonly taken off Barbados in fish-traps at 100 meters.

Chicoreus (Siratus) perelegans Vokes

Murex (Murex) cailleti Petit de la Saussaye. CLENCH and PÉREZ FARFANTE, 1945, Johnsonia, v. 1, no. 17, p. 17 [in part, not of Petit de la Saussaye], pl. 9, figs. 5, 6.

Chicoreus (Siratus) perelegans VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 196 (*n.n. pro Murex elegans* Beck *in* Sowerby, 1841, *non M. elegans* Donovan, 1804, *nec* Wood, 1828).

Siratus perelegans (Vokes). RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 107, pl. 17, fig. 11; FAIR, 1976, The Murex Book, p. 66, not pl. 5, fig. 66 [= *C.(S.) cailleti* (Petit de la Saussaye)].

Lectotype: Brit. Mus. (Nat. Hist.), specimen figured by Reeve, 1845, pl. 24, fig. 99 (designated by Vokes, 1965a, p. 196).

Type locality: Island of St. Domingo, West Indies [Hispaniola] (Reeve, 1845, pl. 24) (designated by Vokes, 1965a, p. 196).

Occurrence: Recent only, Hispaniola to Barbados.

Discussion: Although this species was considered a synonym of *C. (S.) cailleti* by Clench and Pérez Farfante (1945, p. 17) and Abbott (1974, p. 173), it may be distinguished by its heavy appearance, the prominent spiral brown lines, and, especially, by the complete lack of any varical spines and only the most minimal of varical flanges.

Chicoreus (Siratus) aguayoi (Clench and Pérez Farfante)

Murex (Murex) aguayoi CLENCH and PÉREZ FARFANTE, 1945, Johnsonia, v. 1, no. 17, p. 15, pl. 8, figs. 1-3; VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 96.

Chicoreus (Siratus) aguayoi (Clench and Pérez Farfante). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 195.

Siratus aguayoi (Clench and Pérez Farfante). FAIR, 1976, The Murex Book, p. 19, pl. 6, fig. 71 (holotype).

Holotype: Harvard Mus. Comp. Zool., MCZ 174286; height 65 mm, diameter (excluding spines) 24 mm.

Type locality: *Atlantis* Station 3415, off Punta Alegre, Camagüey Province, Cuba.

Occurrence: Recent only, Bahamas to Cuba.

Discussion: Although compared to "*Murex antillarum*" [= *C.(S.) formosus* (Sowerby)] by Clench and Pérez Farfante (1945, p. 17) and placed in synonymy with *C.(S.) formosus* by Radwin and D'Attilio (1976, p. 106) this species may be distinguished by two important criteria. One is the unusual protoconch, which is large, bulbous, of two whorls with the first noticably larger than the second and rotated at an angle to the rest of the shell. The second criterion is the extremely deflected siphonal canal, which is closer to the group of *C.(S.) motacilla* than to *C.(S.) formosus*. If it were not for the unusual protoconch, I would suggest that *C.(S.) aguayoi* is only an extremely spinose form of *C.(S.) cailleti* var. *kugleri*, which is otherwise similar.

Chicoreus (Siratus) carolynae Vokes

Murex chrysostoma Sowerby, var? RIOS, 1970, Coastal Brazilian Seashells, p. 77, pl. 21; RIOS, 1975, Brazilian Marine Moll. Icon., p. 84, pl. 24, fig. 339.

Murex chrysostoma Sowerby. RIOS, 1985, Seashells of Brazil, p. 81, pl. 29, fig. 354 (not of Sowerby).

Chicoreus (Siratus) carolynae VOKES, 1990, Nautilus, v. 103, no. 4, p. 126, text-figs. 1-6.

Holotype: USNM 860504; height 52.8 mm, diameter 24.4 mm.

Type locality: Ilha de Itaparica, Bahia, Brazil, at low tide.

Occurrence: Recent only, Bahia, Brazil.

Discussion: This species was confounded by Rios with *Haustellum chrysostoma*, but the resemblance is only superficial, as both have three essentially nonspinose varices and brown color bands. There is a closer relationship to the members of the *C.(S.) motacilla* group but the siphonal canal of *C.(S.) carolynae* is not so strongly deflected.

The species does closely resemble an aberrant form of *Haustellum messorius* (Sowerby) with a recurved siphonal canal and it may be a case of "ontogeny reversing phylogeny," if, as I suspect, the origin of the *Haustellum* line was a derivative form of *Siratus* in which the siphonal canal became straightened.

Subgenus PHYLLONOTUS Swainson, 1833

Phyllonotus SWAINSON, 1833, Zool. Illus., (Ser. 2) v. 3, expl. to pl. 100.

Type species: *Murex imperialis* var. *a* Swainson, 1833, by subsequent designation, Swainson, 1833, pl. 109 (*M. imperialis* var. *a* = *M. imperialis* Swainson, 1831, *non M. imperialis* Fischer von Waldheim, 1807, = *M. margaritensis* Abbott, 1958).

Discussion: As with the subgenus *Siratus*, the history of development of the subgenus *Phyllonotus* also is rather uncertain. The earliest species in the entire *Chicoreus* complex is one from the Middle Eocene Weches Formation of Texas, here named *C.(P.) initialis*. It most closely resembles the later species *C.(P.) folidodes* (Gardner) and *C.(P.) aldrichi* (Gardner), and for this reason is here placed in *Phyllonotus*. It is similar to *Siratus* with its flanged varices, but the canal is too short for assignment to *Siratus*. However, it almost certainly is ancestral to *C.(S.) stetopus* (de Gregorio) (see above). Also, it is close to the early members of *Chicoreus* s.s., such as *C. dujardinoides* (Vokes) and *C. lepidotus* (Vokes), but the siphonal canal is shorter and more sharply recurved and the varical ornamentation is not divided into discrete spines. It even resembles the subgenus *Naquetia* but again the canal is too short and too recurved and the varical flange is not so elaborately fimbriated as in that group. Thus, in *C.(P.) initialis*, we have a good candidate for the ancestor of all of these groups: giving rise to *Siratus* by lengthening the canal; to *Chicoreus* by dividing the flange into fronds; to (pseudo-) *Naquetia* (see more below) by elaborating the varical flange; and, to *Phyllonotus* by developing a rugose, expanded parietal shield.

Chicoreus (Phyllonotus) initialis Vokes, n. sp.

Plate 9, figures 1, 2

Description: Shell with six teleoconch whorls and a protoconch of probably five conical whorls [not completely preserved in any specimen], ending at a small varix. Spiral ornamentation on earliest teleoconch whorls worn but about four equal spiral cords, gradually increasing in number and intercalating smaller secondary cords. Body whorl and siphonal canal with 12

primary cords; between each of these one secondary cord, flanked by tertiary threads; entire surface of adult shell covered with a recurring pattern of primary, tertiary, secondary, tertiary, primary cords. Axial ornamentation on first teleoconch whorl of 12 equal ridges; on about fourth teleoconch whorl certain of the ridges enlarged into varices, with others remaining as intervarical nodes; exact pattern somewhat irregular but by fifth and succeeding whorls usually two nodes between each pair of varices. Each varix formed as an expanded flange of shell material, with successively smaller flanges laid down on the adapertural side of the previous ones, giving a multi-layered appearance to the varical face; this flange undulated by the spiral cords but no part extended as spines. Suture deeply incised, giving a rounded appearance to each whorl. Aperture oval, inner lip narrow, smooth, appressed at posterior end, free-standing at anterior end. Inner side of outer lip with eight heavy denticles, corresponding to the space between the major spiral cords. Siphonal canal short, broad, strongly recurved, previous canals fused into succeeding canals forming a twisted fasciole.

Holotype: USNM 450376; height 29.2 mm, diameter 16 mm.

Type locality: TU 1258, Weches Formation; west side of spillway and dam of Lake Nacogdoches, north side of Texas Highway FM 225, 10 mi west of Texas Highway 224 Bypass, at Nacogdoches, Nacogdoches County, Texas.

Etymology of name: *initialis* (L.) = first, original.

Occurrence: Weches and Stone City formations, Texas.

Figured specimens: Fig. 1, USNM 450376 (holotype). Fig. 2, USNM 450377 (paratype); height 18.7 mm, diameter 10.5 mm; locality TU 1527. Additional locality: TU 61.

Discussion: As noted above, *C.(P.) initialis* is an ideal ancestor for all branches of the genus *Chicoreus;* but, it cannot readily be assigned to any one of these branches. It is most similar to members of the subgenus *Phyllonotus,* with a short, strongly recurved siphonal canal but it differs from that group in lacking the rugose, expanded parietal shield. However, this expanded shield is a later development of the group and the early members do not possess this feature. By the latest Oligocene, species in the Tampa and Silverdale formations show the rugae on the inner lip and in the Early Miocene *C.(P.) infrequens* the labium is beginning to expand.

The only species this new form resembles are *C.(P.) folidodes,* from the Early Miocene, and *C.(P.) aldrichi,* from the Middle Miocene. Both of these later species lack the expanded varical flange of *C.(P.) initialis.*

The type and paratype specimens of *C.(P.) initialis* were originally collected by Thomas G. Andrews, Jr., at the time a graduate student at Stephen F. Austin State University, Nacogdoches, Texas. He included the species in his thesis, as "*Chicoreus (Phyllonotus)* n. sp." (Andrews, 1975, pl. 10, figs. 3, 4), but he had no further interest and gave the specimens to me to describe.

Chicoreus (Phyllonotus) mississippiensis (Conrad)

Plate 9, figure 3

Chicoreus (Phyllonotus) mississippiensis (Conrad). VOKES, 1967, Tulane Stud. Geol., v. 5, no. 3, p. 136, pl. 1, figs. 6, 7; MACNEIL and DOCKERY, 1984, Mississippi Bur. Geol., Bull. 124, p. 122, pl. 18, figs. 17-19, pl. 31, figs. 12-14, pl. 51, fig. 7 [as *C.(P.) mississippiensis?*].

Murex mississippiensis Conrad. DOCKERY, 1982, Mississippi Bur. Geol., Bull. 123, Appendix 1, p. 232, reprint of Conrad's 1848 plates, with pl. XI, fig. 30, *Murex mississippiensis.*

Chicoreus (Phyllonotus) stetopus (de Gregorio). MACNEIL and DOCKERY, 1984, Mississippi Bur. Geol., Bull. 124 [in part, not of de Gregorio], pl. 4, fig. 17 only.

Lectotype: Acad. Nat. Sci. Philadelphia, ANSP 13482 (designated by MacNeil *in* Moore, 1962, p. 77).

Type locality: (?)Byram Formation, Vicksburg, Mississippi.

Occurrence: Red Bluff, Mint Springs, and Byram formations, Mississippi; unnamed formation, Nuevo Leon, Mexico.

Figured specimen: USNM 645427; height 20 mm, diameter 11 mm; locality TU 76. Additional localities TU 1458, 1460.

Discussion: The relationship between the various forms of *Chicoreus* from the Oligocene of Mississippi is not much better understood than when I originally studied the group (Vokes, 1967b). However, numerous additional specimens from the Early Oligocene Red Bluff Formation have caused me to separate *C. stetopus* as an early form of *Siratus* rather than *Phyllonotus,* where I originally placed it (Vokes, 1967b, p. 138). It occurs with, and is difficult to separate from, the more coarsely ornamented *C.(P.) mississippien-*

sis (compare MacNeil and Dockery, 1984, pl. 4, figs. 16 and 17, for example).

Based on material in the Tulane collections, *C.(S.) stetopus* and *C.(P.) mississippiensis* occur in both the Red Bluff and the Mint Springs formations; and *C.(P.) mississippiensis* and *C.(P.) dormani* occur in the Mint Springs and Byram formations. Perhaps *C.(S.) stetopus* gave rise to *C.(P.) dormani* – both are smooth and have a varical flange. If so, this is an amazing case of convergence because *C. dormani* also intergrades with *C. mississippiensis* and is difficult to separate at times. It is awkward

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PLATE 9

Figures Page

1, 2. *Chicoreus (Phyllonotus) initialis* Vokes, n. sp. 56
1. (X 1 1/2) USNM 450376 (holotype); height 29.2 mm, diameter 16 mm.
Locality: TU 1258, Texas; Weches Formation.
2. (X 2) USNM 450377 (paratype); height 18.7 mm, diameter 10.5 mm.
Locality: TU 1527, Texas; Weches Formation.

3. *Chicoreus (Phyllonotus) mississippiensis* (Conrad) (X 2) 57
USNM 645427; height 20 mm, diameter 11 mm.
Locality: TU 76, Mississippi; Mint Springs Formation.

4. *Chicoreus (Phyllonotus) dormani* (Vokes) (X 2) 60
ANSP 13483; height 24.7 mm, diameter 15 mm.
Locality: Vicksburg, Mississippi; Byram Formation.

5. *Chicoreus (Phyllonotus) davisi* (Richards) (X 1) 60
USNM 645425; height 46 mm, diameter 27 mm.
Locality: TU 562, North Carolina; Silverdale Beds.

6. *Chicoreus (Phyllonotus) trophoniformis* (Heilprin) (X 1 1/2) 60
USNM 165085; height 30 mm, diameter 16.5 mm.
Locality: Ballast Point, Tampa Bay, Florida; Tampa Limestone.

7. *Chicoreus (Phyllonotus) tritonopsis* (Heilprin) (X 2) 61
USNM 643748; height 23.5 mm, diameter 16 mm.
Locality: Ballast Point, Tampa Bay, Florida; Tampa Limestone.

8, 9. *Chicoreus (Phyllonotus) louisae* Vokes, n. sp. (X 3) 61
8. USNM 371878 (paratype); height 14.5 mm, diameter 8.3 mm.
Locality: USGS2211, Alum Bluff, Florida; Chipola Formation.
9. USNM 450378 (holotype); height 16.4 mm, diameter 9.2 mm.
Locality: TU 453, Florida; Chipola Formation.

10. *Chicoreus (Phyllonotus) infrequens* (Vokes) (X 1 1/2) 61
USNM 323860; height 29.6 mm, diameter 15.6 mm.
Locality: TU 1364, Dominican Republic; Baitoa Formation.

11. *Chicoreus (Phyllonotus) folidodes* (Gardner) (X 2) 62
USNM 450379; height 25.9 mm, diameter 18 mm.
Locality: TU 546, Florida; Chipola Formation.
(Color pattern under ultraviolet light)

12. *Chicoreus (Phyllonotus) aldrichi* (Gardner)(X 1) 62
USNM 481841; height 45.8 mm, diameter 25.9 mm.
Locality: USGS 9908, Las Cahobas, Haiti; Thomonde Formation.

13. *Chicoreus (Phyllonotus) pyknos* (Gardner) (X 1 1/2) 63
USNM 115771 (holotype); height 32 mm, diameter 20.8 mm.
Locality: USGS 2615, Florida (= TU 69); Shoal River Formation.

14. *Chicoreus (Phyllonotus) millvillensis* (Richards and Harbison) (X 1 1/2) 63
USNM 498975 (holotype); height 32.5 mm, diameter 19 mm.
Locality: Millville, New Jersey; Kirkwood Formation.

15. *Chicoreus (Naquetia) compactus* (Gabb) (X 1 1/2) 70
USNM 323866; height 32.5 mm, diameter 19 mm.
Locality: TU 1230, Dominican Republic; Cercado Formation.

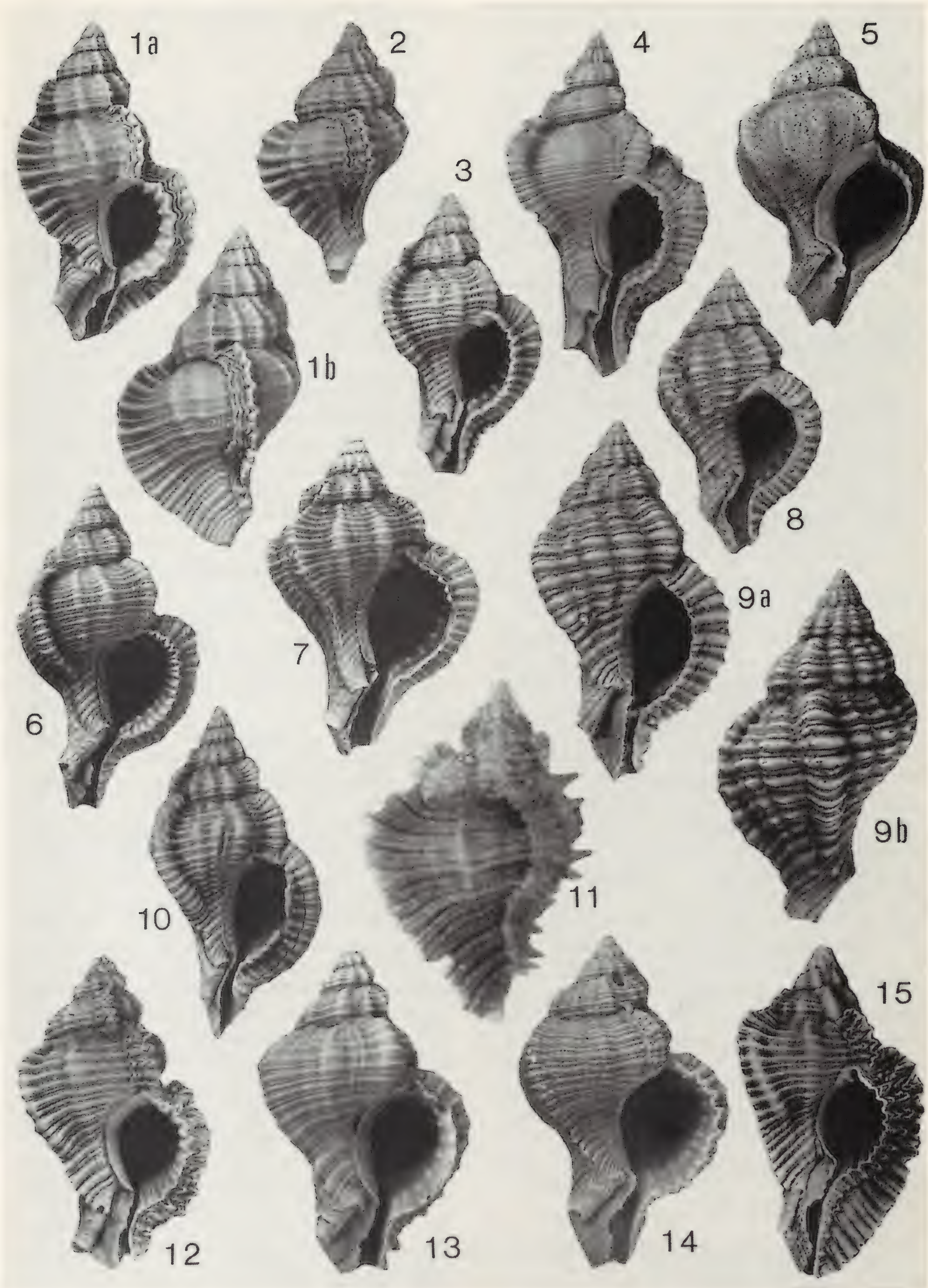


PLATE 9

to place two species into different subgenera when one can barely separate them into two species. Therefore, the arrangement presented here is somewhat arbitrary, but represents the best that can be done at this time. Almost certainly, the problems caused by trying to distinguish these three species are due to the highly plastic nature of these early forms when evolution is rapidly taking place and different variants are appearing simultaneously.

Chicoreus (Phyllonotus) dormani (Vokes)
Plate 9, figure 4

Chicoreus (Phyllonotus) dormani (Vokes). VOKES, 1967, Tulane Stud. Geol., v. 5, no. 3, p. 139, pl. 1, figs. 8, 9; MACNEIL and DOCKERY, 1984, Mississippi Bur. Geol., Bull. 124, p. 123, pl. 31, figs. 9-11.

Holotype: USNM 644373; height 22 mm, diameter 14.8 mm.

Type locality: (?)Byram Formation; Vicksburg, Mississippi.

Occurrence: Byram Formation, Mississippi.

Figured specimen: ANSP 13483; height 24.7 mm, diameter 15 mm; locality, Vicksburg, Mississippi. Additional locality: TU 1203.

Discussion: Chicoreus (Phyllonotus) dormani is closer in appearance to *C. (S.) stetopus* than to *C.(P.) mississippiensis*. If not an example of parallelism, then *C.(P.) dormani* also should be transferred to the subgenus *Siratus*. However, I believe that *C.(P.) dormani* is just a smooth variant of *C.(P.) mississippiensis*, as previously considered. There does seem to be a stratigraphic component to the appearance of *C.(P.) dormani*, which is confined to the Byram Formation.

All three species are obviously very closely related, all have identical protoconchs (see MacNeil and Dockery, 1984, pl. 51, fig. 7, for a beautiful example), and only the development of the varical flange has prompted me to separate the *C.(S.) stetopus* variant as ancestral to the *Siratus* lineage. Of the three species, *C.(P.) dormani* is most similar to Late Oligocene members of *Phyllonotus* from the Tampa and Silverdale formations, offering some assurance that this is the correct phylogenetic sequence.

Chicoreus (Phyllonotus) davisi (Richards)
Plate 9, figure 5

Chicoreus (Phyllonotus) davisi (Richards). VOKES, 1967, Tulane Stud. Geol., v. 5, no. 3, p. 140, pl. 2, fig. 2.

Holotype: Acad. Nat. Sci. Philadelphia, ANSP 15836; height 45 mm, diameter 29 mm.

Type locality: Gillette marl pits, Silverdale, Onslow County, North Carolina (= TU 704).

Occurrence: Silverdale Beds, North Carolina.

Figured specimen: USNM 645425; height 46 mm, diameter 27 mm; locality TU 562.

Discussion: As noted in the Stratigraphic Correlation section (above), the age of the beds at Silverdale is now considered to be Chickasawhayan Stage or latest Oligocene rather than Early Miocene, as originally dated (Vokes, 1967b, p. 140).

This species is noteworthy for it is the first to show the free-standing anterior portion of the inner lip, on which small rugae may be developed. The function of these rugae is uncertain, but through time they become an increasingly visible characteristic in this subgenus.

Chicoreus (Phyllonotus) trophoniformis (Heilprin)
Plate 9, figure 6

Chicoreus (Phyllonotus) trophoniformis (Heilprin). VOKES, 1967, Tulane Stud. Geol., v. 5, no. 3, p. 140, pl. 2, figs. 7, 8.

Holotype: Wagner Free Institute of Science, Philadelphia, no. 869; height (incomplete) 30.5 mm, diameter 20.3 mm.

Type locality: Ballast Point, Tampa Bay, Hillsborough County, Florida.

Occurrence: Tampa Limestone, Florida.

Figured specimen: USNM 165085; height 30 mm, diameter 16.5 mm; locality, Ballast Point, Tampa Bay, Florida.

Discussion: This species occurs in beds that are now thought to be Chickasawhayan in age, or slightly older than previously believed. The inner lip remains very narrow, but even more than in *C.(P.) davisi* the labial rugae are a conspicuous ornament in the aperture. This trend continues into the next species of this lineage, the Early Miocene *C.(P.) infrequens*, which occurs in the Baitoa and Chipola formations.

Although Heilprin's *Explorations on the West Coast of Florida* is dated as 1887, Petit and Wilson (1986, p. 95) have shown that pp. 65-127 were distributed originally in 1886 and the earlier pages were "unavoidably delayed" and published the next year.

Thus, the date of publication for the Heilprin species of *Phyllonotus,* both on p. 107, should be 1886 and not 1887, as previously cited.

Chicoreus (Phyllonotus) tritonopsis (Heilprin)
Plate 9, figure 7

Chicoreus (Phyllonotus) tritonopsis (Heilprin). VOKES, 1967, Tulane Stud. Geol., v. 5, no. 3, p. 141, pl. 2, figs. 1, 5.

Holotype: Wagner Free Institute of Science, Philadelphia, no. 868; height 30.5 mm, diameter 17.8 mm.

Type locality: Ballast Point, Tampa Bay, Hillsborough County, Florida.

Occurrence: Tampa Limestone, Florida.

Figured specimen: USNM 643748; height 23.5 mm, diameter 16 mm; locality, Ballast Point, Tampa Bay, Florida.

Discussion: Although occurring with *C.(P.) trophoniformis* at Ballast Point, *C.(P.) tritonopsis* may be distinguished by the more regular appearance of the varices and the heavier spiral ornamentation. It is ancestral to the Middle Miocene species *C.(P.) pyknos* (Gardner) and *C.(P.) millvillensis* (Richards and Harbison), both of which have a similar general appearance but differ in minor details of ornamentation.

Chicoreus (Phyllonotus) louisae Vokes, n. sp.
Plate 9, figures 8, 9

Chicoreus (Phyllonotus) cf. *tritonopsis* (Heilprin). VOKES, 1967, Tulane Stud. Geol., v. 5, no. 3, p. 142, pl. 2, fig. 6.

Description: Shell with only five teleoconch whorls in all material studied but almost certainly more in an adult; protoconch of one and one-half smooth whorls, ending at a small varix. Spiral ornamentation on the earliest teleoconch whorls of three or four narrow sharp cords, increasing in strength and number up to 12 on the body whorl and siphonal canal. Smaller secondary cords gradually intercalated, with on some specimens an additional secondary cord on the subsutural ramp. Axial ornamentation on first teleoconch whorl of about 15 small equal ridges, decreasing to 12 on second and succeeding teleoconch whorls; on about fourth whorl every third ridge somewhat enlarged to form a small rounded varix, the others remaining as rounded intervarical ridges, normally two between each pair of varices. Varices ornamented only by the spiral cords forming slight welts as they pass over. Suture undulated by the axial ornamentation. Aperture oval, inner lip thin, appressed over its entire length; crenulated by underlying spiral cords, but also with numerous rugae superimposed on top of this pattern. Inner side of outer lip with eight heavy denticles, corresponding to the spaces between the major spiral cords. One strong denticle on the posterior end of the inner lip, forming a small anal notch, not visible from exterior. Siphonal canal short, recurved, open by a narrow slit; terminations of preceeding canals fused into succeeding canal, forming a small fasciole.

Holotype: USNM 450378; height 16.4 mm, diameter 9.2 mm.

Type locality: TU 453, Chipola Formation; Alum Bluff (lower beds), Apalachicola River (NE 1/4 Sec. 24, T1N, R8W), Liberty County, Florida.

Etymology of name: Named in honor of Louise (Mrs. W. D.) Compton, Marietta, Georgia, who kindly donated the holotype specimen.

Occurrence: Chipola Formation, Florida.

Figured specimens: Fig. 8, USNM 371878 (paratype); height 14.5 mm, diameter 8.3 mm; locality USGS 2211, Alum Bluff, Florida. Fig. 9, USNM 450378 (holotype). Additional locality: TU 830.

Discussion: This new species was cited by Gardner (1947, p. 522) as "Incertae sedis," as she had only the paratype specimen (USNM 371878) to examine and it does not offer many diagnostic characteristics. However, an additional three specimens (the holotype and two unfigured paratypes) in the collections of Mrs. Louise Compton, of Marietta, Georgia, from the type locality, and one from the lower beds of the Chipola Formation on Tenmile Creek are now available. All are small (the holotype is the largest) but the species likely attained a larger size. That most examples come from the lower beds at Alum Bluff indicates a shallow-water habitat.

As indicated by the citiation "*C.(P.)* cf. *tritonopsis,*" previously used (Vokes, 1967b, p. 142), there is a marked resemblance to the older *C.(P.) tritonopsis* but the new species is much narrower in outline, and lacks the almost diamond-shaped outline of *C.(P.) tritonopsis.*

Chicoreus (Phyllonotus) infrequens (Vokes)
Plate 9, figure 10

Chicoreus (Phyllonotus) infrequens (Vokes). VOKES, 1967, Tulane Stud. Geol., v. 5, no. 3, p. 143, pl. 1, fig. 10; VOKES, 1972, Earth Sci., v. 25, no. 3, p. 124, pl. 2, fig. 5; VOKES, 1989,

Bulls. Amer. Paleontology, v. 97, no. 332, p. 39, pl. 2, fig. 5.

Holotype: USNM 644374; height 36 mm, diameter 19 mm.

Type locality: TU 458, Chipola Formation; Chipola River above Farley Creek (SW 1/4 Sec. 20, T1N, R9W), Calhoun County, Florida.

Occurrence: Chipola Formation, Florida; Baitoa Formation, Dominican Republic.

Figured specimen: USNM 323860; height 29.6 mm, diameter 15.6 mm; locality TU 1364. Additional localities: TU 459, 555, 786, 820, 825, 830, 950, 951, 998, 1048, 1098, 1196.

Discussion: In the years since *C.(P.) infrequens* was described we have collected it at a number of localities but, as the name implies, it is never common. Rarely do we have more than one or two specimens from any locality but it occurs in every Chipola facies, from Tenmile Creek, Farley Creek, and the Chipola River. In addition, we collected three examples in the Baitoa Formation, Dominican Republic (TU 1364); one is figured here (pl. 9, fig. 10).

Chicoreus (Phyllonotus) folidodes (Gardner)
Plate 9, figure 11

Chicoreus (Phyllonotus) folidodes (Gardner). VOKES, 1965, Tulane Stud. Geol., v. 5, no. 3, p. 143, pl. 3, fig. 1; VOKES, 1972, Earth Sci., v. 25, no. 3, p. 124, pl. 2, fig. 1.

Holotype: USNM 371852; height 43.3 mm, diameter 25 mm.

Type locality: USGS 3419, Chipola Formation; "one mile below Bailey's Ferry," Chipola River, Calhoun County, Florida (= TU 457).

Occurrence: Chipola Formation, Florida.

Figured specimen: USNM 450379; height 25.9 mm, diameter 18 mm; locality TU 546. Additional localities: TU 655, 810, 830, 951, 1020, 1050, 1098.

Discussion: In the previous discussion of *C.(P.) folidodes* (Vokes, 1967b, p. 144), it was noted that the species had been collected only along the Chipola River or at the eastern end of Tenmile Creek where the beds are similar in facies to those on the river. Though a great deal more material has been collected from a large number of additional localities, this still holds true. Parker (1948, p. 93) had reported a specimen from under the bridge at Tenmile Creek (= TU 70). We have now collected just one fragment from a nearby locality (TU 655) but this is our only record in the upper beds along Tenmile Creek.

In 1967 the nature of the protoconch was unknown, but additional material shows a polished, conical protoconch of three and one-half whorls. The color pattern of *C.(P.) folidodes* (as revealed by ultra-violet light, pl. 9, fig. 11) is typical of the group, with wide dark bands at the shoulder, the periphery, and base of the body whorl, much like the Recent *C.(P.) pomum*. However, it is also marked by darker threads topping the major spiral cords, in a manner seen only in the Indo-Pacific species *Murex superbus* Sowerby, 1889, type of the subgenus *Chicomurex* Arakawa, 1964.

The subgenus *Chicomurex* is closely allied with *Phyllonotus,* to the point that Radwin and D'Attilio (1976) placed most of the species that I would place in *Chicomurex* into *Phyllonotus*. In my intrepretation, the subgenus *Phyllonotus* is confined to the New World, and is characterized by a rugose, expanded parietal shield. The subgenus *Chicomurex* is confined to the Old World and has a smooth, narrow inner lip.

Should *C.(P.) folidodes* and *C.(P.) aldrichi,* with their smooth, narrow inner lips, therefore, be placed in *Chicomurex*? I do not think so. As noted above, the expanded parietal shield is a late development in the subgenus *Phyllonotus*. None of the species prior to the *C.(P.) globosus* complex have this distinctive inductura, and it is confined to the members of this particular species-complex. Today this species-complex dominates the present makeup of the subgenus, with the majority of the Recent species belonging to this group.

In the Dominican Republic report (Vokes, 1989b, p. 42) I discussed the ancestry of *C. (Naquetia) compactus* (Gabb), which is presumed to be derived from *C.(P.) folidodes* and concluded that there is a great deal of interweaving and overlapping of the supposed subgenera of the genus Chicoreus. Presumably, the ancestral *Phyllonotus* type gave rise not only to "pseudo-*Naquetia*" in the New World, as in *C. compactus,* but also generated a form that is repeated in the Indo-Pacific subgenus *Chicomurex*.

Chicoreus (Phyllonotus) aldrichi (Gardner)
Plate 9, figure 12

Murex (Phyllonotus) compactus Gabb. WOODRING, BROWN, and BURBANK, 1924, Geol. Rep. Haiti, p. 183 (not of Gabb).

Chicoreus (Phyllonotus) aldrichi (Gardner). VOKES, 1967, Tulane Stud. Geol., v. 5, no. 3, p. 144, pl. 3, fig. 2.

Holotype: USNM 645424; height 53.5 mm, diameter 31.5 mm.

Type locality: Aldrich Coll. 3472, Shoal River Formation; Shell Bluff, Shoal River, Walton County, Florida (= TU 69).

Occurrence: Shoal River Formation, Florida; Thomonde Formation, Haiti.

Figured specimen: USNM 481841; height 45.8 mm, diameter 25.9 mm; locality USGS 9908, Rivière l'Ayaye, Arrondissement of Las Cahobas, Haiti.

Discussion: There is no additional Florida material available of *C. (P.) aldrichi,* since Gardner first described her unique specimen. Thus, it was a pleasant surprise to discover among material collected in eastern Haiti by members of the U. S. Geological Survey (U.S. National Museum collections), a second example of this rare species. It was cited as *Murex (Phyllonotus) compactus* Gabb by Woodring *et al.* (1924, p. 183), which is not surprising, as I consider *C.(P.) aldrichi* ancestral to *C.(N.) compactus.*

As *C. folidodes* is the species of this lineage that occurs in the late Early Miocene Chipola Formation, and *C. aldrichi* occurs in the Middle Miocene Shoal River Formation, the presence of the latter species in the Thomonde Formation may indicate a Middle Miocene age, not late Early Miocene as considered by Cooke *et al.* (1943).

The differences between *C.(P.) folidodes* and *C.(P.) aldrichi* are minor. The older species is triangular, as a result of the subsutural slope being more nearly at right angles to the suture, and the intervarical nodes are small, tightly compressed, and project as distinct knobs in larger specimens. In contrast, *C.(P.) aldrichi* is more rounded in outline and the intervarical ornamentation is more ridge-like. The spiral ornamentation is much stronger in *C.(P.) aldrichi;* larger specimens of *C.(P.) folidodes* are almost smooth.

Chicoreus (Phyllonotus) pyknos (Gardner)
Plate 9, figure 13

Chicoreus (Phyllonotus) pyknos (Gardner). VOKES, 1967, Tulane Stud. Geol., v. 5, no. 3, p. 145, pl. 2, fig. 4.

Holotype: USNM 115771; height 32 mm, diameter 20.8 mm.

Type locality: USGS 2615, Shoal River Formation; Shell Bluff, Shoal River, Walton County, Florida (= TU 69).

Occurrence: Shoal River Formation, Florida.

Figured specimen: USNM 115771 (holotype).

Discussion: There is no new information on this species, which occurs rarely in the Shoal River Formation.

Chicoreus (Phyllonotus) millvillensis (Richards and Harbison)
Plate 9, figure 14

Chicoreus (Phyllonotus) millvillensis (Richards and Harbison). VOKES, 1967, Tulane Stud. Geol., v. 5, no. 3, p. 146, pl. 2, fig. 3.

Holotype: USNM 498975; height 32.5 mm, diameter 19 mm.

Type locality: Kirkwood Formation; Millville, New Jersey.

Occurrence: Kirkwood Formation, New Jersey.

Figured specimen: USNM 498975 (holotype).

Discussion: There is no additional information for this species, which was described from a well, at depths of 460 and 505 feet (140 and 154 meters), and attributed by the authors to the Kirkwood Formation, of Middle Miocene age.

Chicoreus (Phyllonotus) pomatus Vokes
Plate 10, figure 1

Chicoreus (Phyllonotus) pomatus VOKES, 1989, Bulls. Amer. Paleontology, v. 97, no. 332, p. 39, pl. 2, figs. 1, 2.

Holotype: USNM 323857; height 52.8 mm, diameter 32.3 mm.

Type locality: TU 1215, Gurabo Formation; Río Gurabo, bluffs on both sides, from the ford on the Los Quemados-Sabaneta road upstream to approximately 1 km above the ford, Dominican Republic (= Zone D of Maury, 1917).

Occurrence: Cercado and Gurabo formations, Dominican Republic.

Figured specimen: USNM 323857 (holotype).

Discussion: This newly discovered species is probably ancestral to the Recent Brazilian species *C.(P.) oculatus* (Reeve, 1845) and the eastern Pacific *C.(P.) peratus* (Keen, 1960). This conclusion is based on the nature of the protoconch, of three and

one-half conical whorls, common to all three species, plus the fact that the three share a less expanded inductura than is typical of the other members of the group.

Occurring in the Late Miocene Cercado Formation and the Early Pliocene Gurabo Formation, *C.(P.) pomatus* is the oldest species yet known of the modern morphotype of *Phyllonotus*. Whether it also is ancestral to the *C.(P.) globosus* species-complex (see below) is uncertain; however, there is no other likely candidate.

CHICOREUS (PHYLLONOTUS) RIPARIUS (Vokes)
Plate 10, figure 2

Chicoreus (Phyllonotus) riparius (Vokes). VOKES, 1967, Tulane Stud. Geol., v. 5, no. 3, p. 147, pl. 3, fig. 4.

Holotype: USNM 644375; height 22.5 mm, diameter 12 mm.

Type locality: TU 60, Jackson Bluff Formation; Jackson Bluff, Ochlockonee River, Leon County, Florida.

Occurrence: Jackson Bluff Formation and Pinecrest Beds, Florida.

Figured specimen: USNM 644375 (holotype). Additional localities: TU 1000, 1524.

Discussion: Although *C.(P.) riparius* was originally described from the "Choctawhatchee Formation" (the "*Cancellaria* Faunizone" of the Choctawhatchee Formation, which has been elevated to the Choctawhatchee Group, now known as the Jackson Bluff Formation), we have collected several specimens from the correlative Pinecrest Beds in the vicinity of Sarasota, Florida.

If *C.(P.) pomatus* is the first of the "new" line of modern species of *Phyllonotus*, then *C.(P.) riparius* is the last of the old line. It has the smooth, narrow inner lip characteristic of the older species, and it is relatively small. All of the specimens from northern Florida are less than 25 mm in height, but from the Sarasota area we have one example almost 40 mm in height.

CHICOREUS (PHYLLONOTUS) LEONENSIS Vokes
Plate 10, figures 3, 4

Chicoreus (Phyllonotus) leonensis VOKES, 1967, Tulane Stud. Geol., v. 5, no. 3, p. 147, pl. 6, figs. 1, 2.

PLATE 10

Figures — Page

1. *Chicoreus (Phyllonotus) pomatus* Vokes (X 1 1/4) 63
   USNM 323857 (holotype); height 52.8 mm, diameter 32.3 mm.
   Locality: TU 1215, Dominican Republic; Gurabo Formation.
2. *Chicoreus (Phyllonotus) riparius* Vokes (X 2) 64
   USNM 644375 (holotype); height 22.5 mm, diameter 12 mm.
   Locality: TU 60, Florida; Jackson Bluff Formation.
3, 4. *Chicoreus (Phyllonotus) leonensis* Vokes 64
   3. (X 3/4) USNM 450380; height 81.5 mm, diameter 53.4 mm.
   Locality: TU 1000, Florida; Pinecrest Beds.
   4. (X 10) USNM 450381; height 27.5 mm, diameter 15.3 mm.
   Locality: TU 1000, Florida; Pinecrest Beds.
5, 6. *Chicoreus (Phyllonotus) globosus* (Emmons) 66
   5. (X 3/4) USNM 878011; height 94 mm, diameter 58.2 mm.
   Locality: Bahía de Mochina, Venezuela; Recent.
   6. (X 1) USNM 450382; height (as is) 72 mm, diameter (as is) 44.5 mm.
   Locality: TU 965, Panama; Gatun Formation.
7. *Chicoreus (Phyllonotus) pomum* (Gmelin) (X 1) 67
   USNM 323859; height 65 mm, diameter 44.8 mm.
   Locality: TU 1352, Dominican Republic; Mao Formation.
8. *Chicoreus (Phyllonotus) oculatus* (Reeve) (X 3/4) 69
   USNM 792359; height 67.9 mm, diameter 43.2 mm.
   Locality: Salvador, Bahia, Brazil; Recent.
9. *Chicoreus (Phyllonotus) margaritensis* (Abbott) (X 3/4) 68
   UCMP 38655; height 87.8 mm, diameter 73 mm.
   Locality: UCMP S-113, Araya Peninsula, Venezuela; Cumaná Formation.

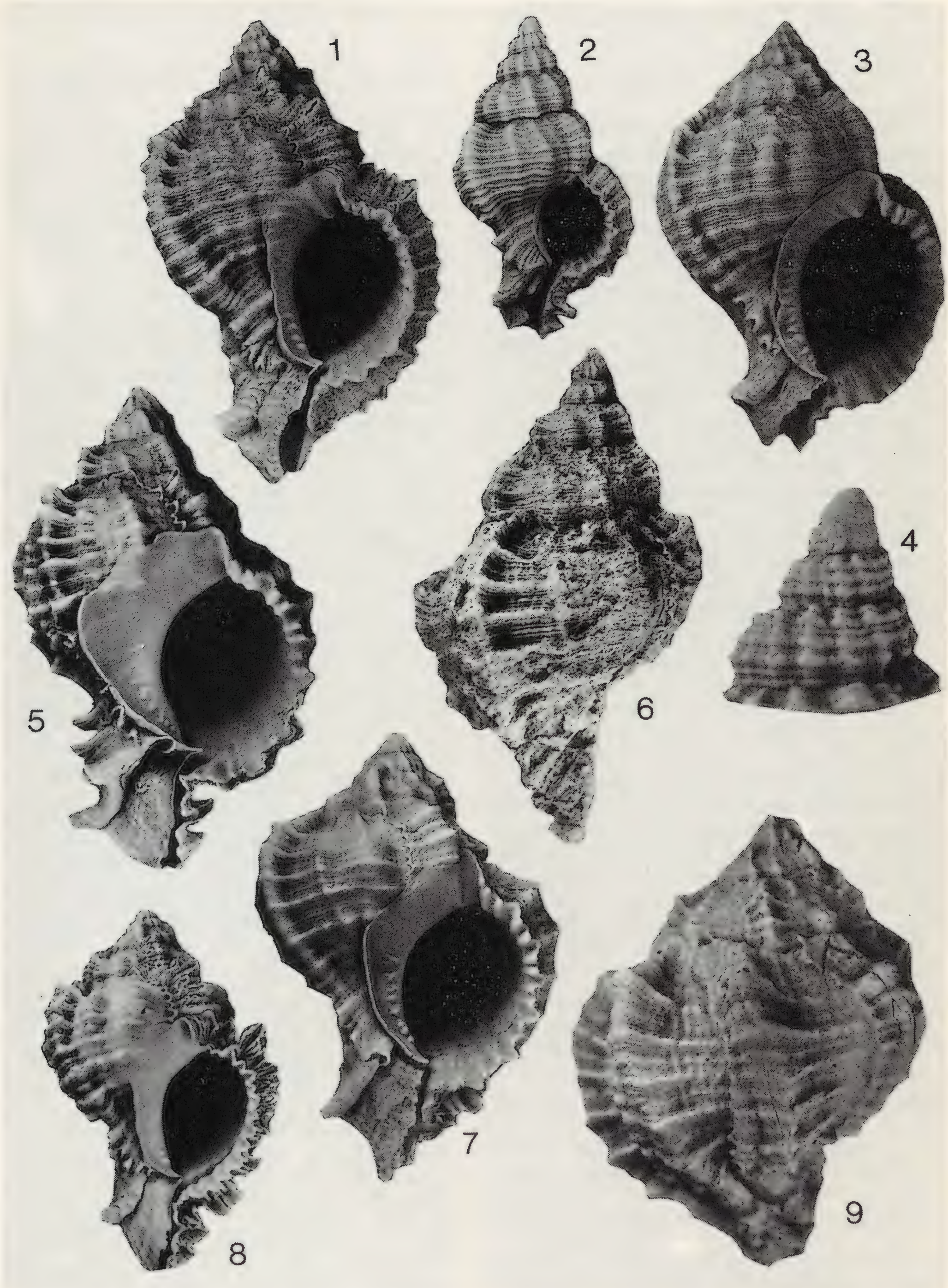


PLATE 10

Holotype: USNM 370189; height 79 mm, diameter (incomplete) 40 mm.

Type locality: Jackson Bluff Formation; Harvey's Creek, 0.5 mi above abandoned mill (Florida Geological Survey Coll.)

Occurrence: Jackson Bluff Formation and Pinecrest Beds, Florida.

Figured specimen: Fig. 3, USNM 450380; height 81.5 mm, diameter 53.4 mm; locality TU 1000. Fig. 4, USNM 450381; height 27.5 mm, diameter 15.3 mm; locality TU 1000. Additional locality: TU 1349.

Discussion: This species, also described from the "Choctawhatchee Formation" (now the Jackson Bluff Formation), likewise has been collected in the Pinecrest Beds in the vicinity of Sarasota. It occurs with the more abundant *C.(P.) globosus* but may be distinguished by the lack of any varical spines in *C.(P.) leonensis,* by the relatively low intervarical ridges, and by the rounded varices, which are deeply excavated on the abapertural side. The inductura is narrower in *C.(P.) leonensis,* much like that of *C.(P.) pomatus*. From the latter species it differs in having a more subdued ornamentation, in lacking any spinose processes even on the early whorls, and also a larger size (the largest specimen seen of *C. pomatus* is only 55 mm in height). From *C.(P.) pomum,* which occurs only in younger beds in Florida, it differs in having a narrower inductura, more subdued ornamentation, and more rounded whorls. At the time of the original description, the nature of the protoconch was unknown. Now, material from the Pinecrest Beds shows the protoconch to be of three and one-half cylindrical whorls (see pl. 10, fig. 4), similar in general shape to that of *C.(P.) pomum* (see Radwin and D'Attilio, 1976, text-fig. 54) but with more whorls.

Chicoreus (Phyllonotus) globosus (Emmons)
Plate 10, figure 5, 6

Chicoreus (Phyllonotus) globosus (Emmons). VOKES, 1967, Tulane Stud. Geol., v. 5, no. 3, p. 148, pl. 4, figs. 1-3, pl. 5, figs. 1-3; VOKES, 1988, Tulane Stud. Geol. Paleont., v. 21, no. 1, p. 21, pl. 3, figs. 1, 2.

Phyllonotus globosus (Emmons). PETUCH, 1976, Veliger, v. 18, no. 3, p. 322, text-figs. 3, 5, 6; FAIR, 1976, The Murex Book, p. 46, pl. 9, fig. 120; KAICHER, 1979, Card Cat. World-Wide Shells, no. 20 - Muricidae IV, no. 1968.

Phyllonotus margaritensis (Abbott). RADWIN and D'ATTILLIO, 1976, Murex Shells of the World, p. 90 [in part, not of Abbott], pl. 16, fig. 6.

Phyllonotus cf. *globosus* (Emmons). PETUCH, 1987, New Caribbean Moll. Faunas, p. 89, pl. 19, figs. 1, 2.

[?] *Phyllonotus* cf. *globosus* (Emmons). PETUCH, 1988, Neogene History Trop. Amer. Moll., p. 157, pl. 37, fig. 6.

Holotype: Not found.

Type locality: "Miocene of the Cape Fear River." (?)Waccamaw Formation; (?)Neills Eddy Landing, Cape Fear River, Columbus County, North Carolina (= TU 559).

Occurrence: Pinecrest Beds and Caloosahatchee Formation, Florida; Waccamaw Formation, North and South Carolina; Gatun Formation, Panama; Cumaná Formation, Venezuela; (?)Imperial Formation, California; Esmeraldas Beds, Ecuador. Recent, Venezuela.

Figured specimen: Fig. 5, USNM 878011; height 94 mm, diameter 58.2 mm; locality, Isla Larga, Bahía de Mochina, Edo. de Sucre, Venezuela. Fig. 6, USNM 450382; height (as is) 72 mm, diameter (as is) 44.5 mm; locality TU 965. Additional localities: TU 932, 933, 939, 974, 975, 982, 985, 991, 1000, 1023, 1177, 1397, 1399, 1491, 1512, 1524.

Discussion: This, the most widespread and abundant species of *Phyllonotus* in the Pliocene, is a large, distinctive form with an extremely expanded inductura. It gave rise to the living species on the West Coast of tropical America – *C.(P.) erythrostomus* (Swainson, 1831) and *C.(P.) regius* (Swainson, 1821). In Vokes, 1967b (p. 149), I noted material from the Pliocene Imperial Formation of southern California (Museum of Paleontology, University of California, Berkeley, collections). In the same collection there is a single battered specimen from the Cumaná Formation at locality UCMP S-112, Isla Cubagua, Edo. de Nuevo Esparta, Venezuela, together with several examples of *C.(P.) margaritensis.* We have one incomplete shell referable to this species from the Gatun Formation, Panama (pl. 10, fig. 6), and we have collected incomplete examples in the Early Pliocene Esmeraldas beds of Ecuador (see Vokes, 1988, p. 21, pl. 3, fig. 1). In the Pleistocene Bermont Formation of Florida and Moín Formation of Costa Rica, *C.(P.) globosus* is not present but instead the derivative species *C.(P.) pomum* occurs.

Living today along the coast of northern South America there is a group of *Phyl-*

lonotus that truly deserves the title "species-complex." Cipriani (1990) has studied the Venezuelan distribution of these different forms and sums up the problem in these words: "Due to some individuals of *Chicoreus (Phyllonotus)* species showing highly variable shell characters in different localities, analysis of shell meristic characters and Raupian coiling parameters has been applied to descriminate all their shell forms."

Some individuals have five varices and are unmistakably *C.(P.) margaritensis;* some have four varices and may be assigned to *C.(P.) globosus* (for example, that figured by Kaicher, 1979, no. 1968; and pl. 10, fig. 5, herein); but others defy assignment (for example, that figured by Petuch, 1987, pl. 19, figs. 1, 2). Most specimens have either pink or yellow apertures, but some have the typical "pomum" dark blotches around the edge of the parietal shield (for example, that figured by Radwin and D'Attilio, 1976, pl. 16, fig. 6); others have only three varices (like *pomum*) but have pink or yellow apertures. We know from ultra-violet studies that the Pliocene specimens of *C.(P.) globosus* had a light-colored aperture for the dark blotches would show up strikingly under ultra-violet light. However, the potential for a dark aperture must have been present, as demonstrated by *C.(P.) regius* and *C.(P.) eversoni* (D'Attilio, Myers, and Shasky, 1987). Pragmatically, I identify those specimens with five varices as *C.(P.) margaritensis* and those with three or four varices as *C. (P.) globosus* – regardless of the color of the aperture. *Chicoreus (Phyllonotus) pomum* is smaller, invariably with three varices, and dark blotches on the greatly enlarged parietal shield. This latter trait serves to separate it from *C. (P.) oculatus,* which also occurs rarely in the same area (Puerto Frances and Chirimena, and the Archipelago Los Roques: Cipriani, 1990).

Petuch (1976) has reported on a molluscan assemblage from the coast of Venezuela that is dominated by *C.(P.) globosus,* which he noted "was the most voracious predator." He states that "all specimens of *P. globosus* observed were grazing upon *Turritella [variegata* (Linné, 1758)] beds – every specimen collected (over 80) had a *Turritella* tightly held to its mouth" (1976, p. 322). Cipriani (1990) notes that all three species of *Phyllonotus* live on sandy bottoms and *Thalassia* beds, in areas of high concentration of *Arca zebra* (Swainson, 1833).

CHICOREUS (PHYLLONOTUS) POMUM (Gmelin)
Plate 10, figure 7; text-figure 2a

Chicoreus (Phyllonotus) pomum (Gmelin). VOKES, 1967, Tulane Stud. Geol., v. 5, no. 3, p. 149, pl. 4, figs. 4, 5, pl. 5, figs. 4, 5.

Phyllonotus pomum (Gmelin). RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 91, pl. 16, fig. 8, text-fig. 54 (protoconch); FAIR, 1976, The Murex Book, p. 68, pl. 10, fig. 126.

"Type figure": Martini, 1777, Conchylien-Cab., v. 3, pl. 109, fig. 1023 (designated by Vokes, 1967b, p. 152).

Type locality: St. Thomas, Virgin Islands (designated by Clench and Pérez Farfante, 1945, p. 27).

Occurrence: Mao Formation, Dominican Republic; (?)Agueguexquite Formation, Mexico; Caloosahatchee, Bermont and Fort Thompson formations, Florida; Mare Formation, Venezuela; Bowden Formation, Jamaica; Moín Formation, Costa Rica. Unnamed Late Pleistocene formations in Panama, Cuba, South Carolina, and Louisiana. Recent, western Atlantic from North Carolina to Amapá, Brazil.

Figured specimen: USNM 323859; height 65 mm, diameter 44.8 mm; locality TU 1352. Additional localities: TU 638, 731, 792, 953, 954, 973, 974, 977, 978, 1023, 1174, 1239, 1366, 1495, 1496.

Discussion: Chicoreus (Phyllonotus) pomum is "the most abundant and widespread muricine species in the western Atlantic" (Vokes, 1967b, p. 152) but it is not so widespread as formerly believed. Records of *C.(P.) pomum* from the coast of Brazil (e.g., Rios, 1985, p. 82 – "Ceara to Rio de Janiero") are based upon *C.(P.) oculatus* (Reeve), which was shown by Houart (1987) to be unequivocally different. Dr. Rios (written communication, September 22, 1988) advises that he has examined all of the specimens in the collection of the Museu Oceanográfico da FURG, Rio Grande, Brazil, and the only specimens of true *C. pomum* are those collected off Cassipore, Amapá, and Cabo Norte, Amapá (both lots collected by the Oceanographic Vessel *Almirante Saldanha*). All others are *C.(P.) oculatus.*

However, what was lost in Recent distribution, is made up in the Pliocene. We now have four good examples of *C.(P.)*

pomum from the Middle Pliocene Mao Formation, Dominican Republic (pl. 10, fig. 7) and in the Agueguexquite Formation, Mexico (TU 638), we have a number of fragments that may be referable to *C.(P.) pomum* and not to *C.(P.) globosus*, although the quality of the material available is poor. In addition, we have good specimens from the Pleistocene Moín Formation, Costa Rica.

In the Dominican Republic report (Vokes, 1989b, p. 41), I included the Gatun Formation, Panama, in the distribution of this species. However, closer study has caused me to place the specimen from locality TU 965 into *C.(P.) globosus* (see pl. 10, fig. 6) rather than *C.(P.) pomum*. The material from TU 964 also mentioned in that report, is so poorly preserved that I would rather not use it as the basis for stating that *C.(P.) pomum* occurs in the Gatun Formation. But it certainly is present in the Recent fauna of Panama, we have hundreds of specimens from locality TU R-109.

In Vokes, 1967b (p. 154), it was noted that with one exception *C. (P.) pomum* was not known from before the Pliocene. That "exception" was the Bowden Formation, Jamaica, where Woodring figured an unquestionable specimen of *C.(P.) pomum* (1928, pl. 17, fig. 9) from beds he dated as Middle Miocene in age. However, now the Bowden has been dated, using planktic foraminifera, as basal Pleistocene.

In 1967 the Pinecrest and Jackson Bluff (= "Choctawhatchee Formation") beds were considered Late Miocene in age and the first occurrence of *C.(P.) pomum* in the Caloosahatchee Formation was taken to indicate that the species did not appear before the (then) Early Pliocene. We now have specimens in beds of the same age as the Pinecrest and Jackson Bluff (Zone N.20) in more southern areas of the Caribbean (Mao Formation, Dominican Republic; Agueguexquite Formation, Mexico). Thus, my intrepretation that "*C. pomum* evolved in the warmer southern waters and moved into Florida with the advent of warmer Pliocene seas" (Vokes, 1967b, p. 154) is confirmed. Only the timing is slightly changed, and the "warmer seas" become Late Pliocene rather than Early Pliocene as once believed.

Chicoreus (Phyllonotus) margaritensis (Abbott)
Plate 10, figure 9

Chicoreus (Phyllonotus) margaritensis (Abbott). VOKES, 1967, Tulane Stud. Geol., v. 5, no. 3, p. 156, pl. 3, fig. 3.

Phyllonotus margaritensis (Abbott). FAIR, 1976, The Murex Book, p. 57, pl. 11, fig. 135.

Not *Phyllonotus margaritensis* (Abbott). RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 90, pl. 16, fig. 6 [= *C.(P.) globosus* (Emmons)].

Holotype: Not found.

Type locality: "Island of Margarita," Venezuela.

Occurrence: Cumaná Formation, Venezuela. Recent, Venezuela, principally offshore islands, including Netherland Antilles.

Figured specimen: UCMP 38655; height 87.8 mm, diameter 73 mm; locality UCMP S-113, 4 kms west of Manicuare, Araya Peninsula, Edo. de Sucre, Venezuela.

Discussion: Previously, I noted (Vokes, 1967b, p. 158) that in the collections of the Museum of Paleontology, University of California, Berkeley, there were several specimens (10 in all from four localities) of *C.(P.) margaritensis* from the Cumaná Formation, Venezuela, then considered to be Late Pliocene in age. As mentioned above, under Stratigraphic Correlation, these beds are now considered by some to be Early Pleistocene. One of the larger Cumaná specimens is figured (pl. 10, fig. 9) and it can be seen to have six varices. Another large shell has six varices also but all of the smaller specimens have five varices. It would seem that through time the number of varices is decreasing in this species causing it to resemble *C.(P.) globosus* and this may be part of the reason we have difficulty in separating the two forms.

Separating Recent specimens of *C.(P.) margaritensis* from *C.(P.) globosus* is admittedly difficult and somewhat ambiguous. In general, the shells of *C.(P.) globosus* have three or four varices per whorl and normally two (rarely one) intervarical node between each pair of varices. The shell is light in weight and the varices may be ornamented with short open spines or, more commonly, with high raised ridges where the spiral cords cross. Those specimens assigned to *C.(P.) margaritensis* are massive and heavy (for example,

that figured by de Jong and Coomans, 1988, pl. 36, fig. 394), with four varices in the younger stages and one single large intervarical node between each pair; but in the adult stage the varices and nodes merge together and the shell has five varices with no nodes between them.

The two forms do occur together, however, and this raises questions. Is *C.(P.) margaritensis* an extremely variable species that may have three, four, or five varices? May it have either heavy massive shells or light delicate shells? Is there some ecologic reason for what appear to be specific differences? For now, as stated above for *C.(P.) globosus,* I will continue to treat them as different species until I have better data.

CHICOREUS (PHYLLONOTUS) OCULATUS (Reeve)

Plate 10, figure 8; text-figure 2b

Chicoreus (Phyllonotus) oculatus (Reeve). VOKES, 1967, Tulane Stud. Geol., v. 5, no. 3, p. 158, pl. 6, fig. 3; HOUART, 1987, Apex, v. 2, no. 1, p. 7, text-figs. 1-4 (fig. 4, protoconch).

Murex (Phyllonotus) pomum Gmelin. RIOS, 1970, Coastal Brazilian Seashells, p. 78 [in part, not of Gmelin], pl. 22.

Phyllonotus pomum (Gmelin). RIOS, 1975, Brazilian Mar. Moll. Icon., p. 85 [in part, not of Gmelin], pl. 24, fig. 347; RIOS, 1985, Seashells of Brazil, p. 82 [in part, not of Gmelin], pl. 29, fig. 360.

Phyllonotus oculatus (Reeve). FAIR, 1976, The Murex Book, p. 64, pl. 11, fig. 137.

Murex pomum (Gmelin). SUTTY, 1986, Seashell Treasures of the Caribbean, p. 56 [in part, not of Gmelin], text-figs. 58, 59.

Lectotype: Brit. Mus. (Nat. Hist).; height 80 mm, diameter 47 mm.

Type locality: Dominica, Lesser Antilles (designated by Vokes, 1967b, p. 160).

Occurrence: Recent only, Florida Keys, Lesser Antilles to northern South America, and to Rio de Janiero, Brazil.

Figured specimen: USNM 792359; height 67.9 mm, diameter 43.2 mm; locality, Salvador, Bahia, Brazil, 6 meters.

Discussion: Although *C.(P.) oculatus* has been synonymized with *C.(P.) pomum* by many authors, I have always considered it an easily separable, distinct species (Vokes, 1967b, p. 160). This separation was confirmed when Houart (1987) showed that the two forms have completely different protoconchs (text-fig. 2).

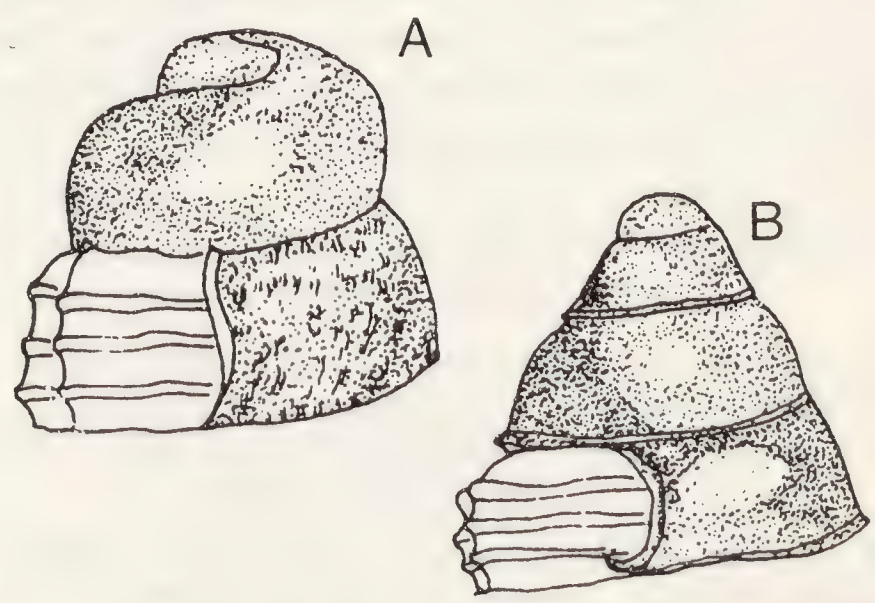
In addition, the two differ in the development of the inductura – the parietal shield, which is greatly expanded in *C.(P.) pomum,* as is typical of the *globosus*-complex (see above), but relatively narrow in *C.(P.) oculatus.* The eastern Pacific *C.(P.) peratus* (Keen, 1960) has generally been considered the Pacific cognate species of *C.(P.) pomum* but in some ways it is more akin to *C.(P.) oculatus* with both having a multiwhorl protoconch and a narrow inductura, although that of *C.(P.) peratus* is more developed than that of *C.(P.) oculatus.*

This species has an extensive range, from the Florida Keys (where it occurs on reefs, in about 6 meters, Kevan Sunderland collection) through the Lesser Antilles (Dominica, Vokes, 1967b, pl. 6, fig. 3; and Guadeloupe, Sutty, 1986, figs. 58, 59), to northern South Amnerica. De Jong and Coomans (1988, p. 72, pl. 36, fig. 393) record the species from the Dutch Antilles (as *Phyllonotus pomum* subspecies *oculatus).* As discussed under *C.(P.) pomum,* all specimens of "*C. pomum*" taken from south of Amapá, in northernmost Brazil, to Rio de Janiero (Rios, 1985, p. 82) are to be referred to *C.(P.) oculatus.* This is the principal area from which most specimens are collected today.

Subgenus NAQUETIA Jousseaume, 1880

Naquetia JOUSSEAUME, 1880, Le Naturaliste, Année 2, no. 42, p. 335.

Type species: *Murex triqueter* Born, 1778, by original designation.



Text-figure 2. Protoconchs of (A) *Chicoreus (Phyllonotus) pomum* and (B) *Chicoreus (Phyllonotus) oculatus* (from Houart, 1987, figures 4 and 6).

Discussion: The Indo-Pacific subgenus *Naquetia* is characterized by an elaborate extension of the varical flange along the siphonal canal, which gives some of its members a certain resemblance to the subgenus *Siratus*. This is particularly true, for example, in specimens of the Indo-Pacific *C.(Naquetia) annandalei* (Preston, 1910) and the Caribbean *C.(S.) consuela,* which are so similar in overall aspect that the two species have often been confused.

Separating these two subgenera is difficult, but in general, *Siratus* develops some type of spinose processes on the varices (although greatly reduced in the case of *consuela* or *perelegans)* and members of *Naquetia* do not. The varical flange is more developed on the siphonal canal than on the body whorl in *Naquetia,* and this proportion is reversed in *Siratus*. In general, the spire is greatly elongated in *Naquetia,* as compared to *Siratus;* but, again, there are exceptions, as in the Red Sea species *C.(N.) jickelii* (Tapparone-Canefri, 1875). The most reliable criterion is the presence of rugae on the inner lip in species of *Siratus,* which are not present in *Naquetia.*

As discussed at length in the Dominican Republic report (Vokes, 1989b, p. 42) lines of distinction between the various subgroups *Siratus, Naquetia, Phyllonotus,* and *Chicomurex* are extremely blurred and the assignment of species is based as much on geography as on morphology. Nevertheless, *C. compactus,* with its varical flange most expanded along the siphonal canal, with no spinose processes, and its smooth inner lip, is better assigned to *Naquetia* than to *Phyllonotus* (from whence it was derived) or *Siratus,* even though the resemblance is due purely to convergence and not to close relationship.

CHICOREUS (NAQUETIA) COMPACTUS (Gabb)
Plate 9, figure 15

Not *Murex (Phyllonotus) compactus* Gabb. WOODRING and VAUGHAN *in* VAUGHAN, *et al.,* 1921, Geol. Surv. Dom. Rep., Mem., v. 1, p. 147 [= *C.(C.) corrigendum* Vokes].

Not *Murex (Phyllonotus) compactus* Gabb. WOODRING, BROWN, and BURBANK, 1924, Geol. Rep. Haiti, p. 183 [= *C.(P.) aldrichi* (Gardner)].

Chicoreus (Chicoreus) compactus (Gabb). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 187, in part, not pl. 2, fig. 3 [= *C.(C.) corrigendum* Vokes].

Chicoreus (Naquetia) compactus (Gabb). VOKES, 1989, Bulls. Amer. Paleontology, v. 97, no. 332, p. 42, pl. 3, figs. 1, 2.

Holotype: Acad. Nat. Sci. Philadelphia, ANSP 3258; height 56.4 mm, diameter 32.3 mm.

Type locality: TU 1230, Cercado Formation; Río Cana, east bank, just above the ford at Caimito on Los Quemados-Sabaneta road, Dominican Republic (= Zone H of Maury, 1917) (restricted by Vokes, 1989b, p. 42).

Occurrence: Cercado and Gurabo formations, Dominican Republic.

Figured specimen: USNM 323866; height 32.5 mm, diameter 19 mm; locality TU 1230. For additional localities in the Dominican Republic, see Vokes, 1989b, p. 43.

Discussion: As was discovered in the course of preparing the Dominican Republic report (Vokes, 1989b), the shell figured in my original treatment of *C.(C.) compactus* is another species, described as *C. (C.) corrigendum.* The two forms are only superficially similar and may be distinguished by the lack in the latter of the broad expanded varical flange on the anterior portion of the varices. It is this flange that gives *C.(N.) compactus* the aspect of the subgenus *Naquetia,* where it is assigned in spite of geographic and phylogenetic contraindications.

Originally I suggested (Vokes, 1965a, p. 188) that *C. compactus* is intermediate between the Chipola species of *Chicoreus* s.s. and the group of *C.(C.) floridanus.* However, *C.(C.) corrigendum* is the intermediary species and not *C.(N.) compactus,* which is the terminal member of the lineage of *C.(P.) folidodes–C.(P.) aldrichi.*

Genus HEXAPLEX Perry, 1810

Hexaplex PERRY, 1810, Arcana, expl. to pl. 23 (genus without species); 1811, Conchology, pl. 8.

Type species: *Hexaplex foliacea* Perry, 1811 (= *Murex cichoreum* Gmelin, 1791), by subsequent designation, Iredale, 1915.

Discussion: In Part IV of *Cenozoic Muricidae* (Vokes, 1968b) I included along with *Hexaplex,* three other supraspecific taxa that are no longer placed in the subfamily Muricinae. These are: *Murexsul* Iredale, 1915; *Murexiella* Clench and Pérez Farfante, 1945; and *Subpterynotus* Olsson and Harbison, 1953. All three are now placed in the subfamily Muricopsinae

and will be reconsidered at such a time as that group is revised, following Part IX (Muricinae – *Pterynotus, Poirieria,* etc.).

Most of the species in the western Atlantic referred to the genus *Hexaplex* are Eocene forms, which resemble the living Mediterranean *Hexaplex trunculus* (Linné, 1758). The latter has been named the type species of several taxa (*Polyplex* Perry, 1810; *Truncularia* Monterosato, 1917; *Truncularіopsis* Cossmann, 1921; and *Murithais* Grant and Gale, 1931). As discussed previously (Vokes, 1968b, p. 86), I do not believe the differences between *H. trunculus* and *H. cichoreum,* type of the genus, are sufficient to separate the two groups at the subgeneric level. As I noted (*ibid.*, footnote) the oldest valid name for the group of *H. trunculus* is *Polyplex,* due to Baily's ill-advised action in designating *Polyplex purpurescens* Perry, 1811, as type. This was set aside by the International Commission on Zoological Nomenclature, in Opinion 911 (1970), and *Polyplex bulbosa* Perry, 1811 (= *Buccinum geversianum* Pallas, 1769) designated as type, making *Polyplex* a synonym of *Trophon* Montfort, 1810.

Likewise, the generic name *Muricanthus* Swainson, 1840, is often employed, especially for species on the west coast of tropical America. In Opinion 886 (1969), the International Commission on Zoological Nomenclature declared the Panamanian species, *Murex radix* Gmelin, 1791, the type of *Muricanthus.* As discussed at length (Vokes, 1988, p. 24), I believe that these species should not be separated from the Indo-Pacific type of the genus.

The result of removing *Murexsul* as a subgenus of the genus *Hexaplex,* plus rejection of *Truncularіopsis* and *Muricanthus* as valid subgenera, leaves no other subgeneric taxa included with *Hexaplex* and no necessity to cite it as *Hexaplex (Hexaplex).*

In the Neogene faunas of the western Atlantic, only a few species of *Hexaplex* lived at any given time. Today, the only certain species is the large, common *H. fulvescens* (Sowerby, 1834), most closely related to the West African fauna. Another, named from the West Indies as *Murex (Aaronia) strausi* Verrill, 1950, is almost certainly conspecific with the Panamanian *H. radix.*

HEXAPLEX TEXANUS Vokes
Plate 11, figure 1

Hexaplex (Hexaplex) texanus VOKES, 1968, Tulane Stud. Geol., v. 6, no. 3, p. 94, pl. 1, fig. 1.

Hexaplex texanus Vokes. GIVENS and KENNEDY, 1976, Jour. Paleontology, v. 50, no. 5, p. 970.

Holotype: Paleont. Resh. Inst., PRI 3000; height 13 mm, diameter 7 mm.

Type locality: Weches Formation; Smithville, Bastrop County, Texas (= TU 243).

Occurrence: Weches Formation, Texas.

Figured specimen: PRI 3000 (holotype).

Discussion: In the original description I stated that this species differs from the slightly younger *H. vanuxemi* by its much higher spire and especially by the denticles on the inner lip. In 1976, Givens and Kennedy (p. 969, pl. 3, figs. 1-6) described from the Eocene of California, *Muricopsis vistaensis,* a species very similar to *H. texanus,* causing them to suggest that *H. texanus* is not closely related to *H. vanuxemi,* and that both *H. texanus* and the younger *H. silvaticus,* should be removed from *Hexaplex* and placed into *Muricopsis.*

They may be correct about *H. texanus.* However, the species that I (Vokes, 1968b, p. 96) called *Hexaplex silvaticus* (Palmer, 1937) is better referred to *Poirieria (Pazinotus)* and may be distinguished from both *Hexaplex* and *Muricopsis* by the smooth shell surface between the major spiral cords. In contrast, *H. texanus, H. vanuxemi* and *H. katherinae* all have elaborately ornamented shells. The difference between *H. texanus* and the other two is the presence of columellar denticulations in *H. texanus.* These denticulations are lacking in *H. vanuxemi* and *H. katherinae.* Nevertheless, these three species are so similar that I cannot place them in two different subfamilies.

HEXAPLEX VANUXEMI (Conrad)
Plate 11, figures 2, 3

Hexaplex (Hexaplex) vanuxemi (Conrad). VOKES, 1968, Tulane Stud. Geol., v. 6, no. 3, p. 94, pl. 1, fig. 3; DOCKERY, 1980, Mississippi Bur. Geol., Bull. 122, p. 99, pl. 35, figs. 2, 3.

Hexaplex vanuxemi (Conrad). GIVENS and KENNEDY, 1976, Jour. Paleontology, v. 50, no. 5, p. 970.

?Synonym:

Murex septemnarius CONRAD, 1834, Acad. Nat. Sci. Phila., Jour., (Ser. 1) v. 7, p. 154; PALMER, 1937, Bulls. Amer. Paleontology, v. 7, no. 32, p. 269; MOORE, 1962, Acad. Nat. Sci. Phila., Proc., v. 114, p. 95; PALMER and BRANN, 1966, Bulls. Amer. Paleontology, v. 48, no. 218, p. 783.

Holotype: Acad. Nat. Sci. Philadelphia, ANSP 13756; height 20 mm, diameter 12 mm.

Type locality: Gosport Sand; Claiborne Bluff, Alabama River, Monroe County, Alabama (= TU 78).

Occurrence: Cook Mountain Formation, Louisiana, Mississippi (= Wautubbee Formation), and Texas (= Crockett Formation); Yegua Formation, Texas; Gosport Sand, Alabama.

Figured specimens: Fig. 2, USNM 450383; height 19.2 mm, diameter (including spine) 13.5 mm; locality TU 1511. Fig. 3, USNM 450384; height 17.5 mm, diameter (including spine) 12.2 mm; locality TU 86.

Discussion: As originally noted (Vokes, 1968b, p. 95), *Hexaplex vanuxemi* occurs in Early and Late Middle Eocene beds from Texas to Alabama. The Early Middle Eocene beds from Texas to Alabama have had a variety of local names. The Wautubbee Formation in Mississippi is now referred to the Cook Mountain Formation (Dockery, 1980, p. 39). In Texas, the beds that Stenzel *et al.* (1957, p. 37) called the Cook Mountain have been referred to the Crockett Formation.

The original illustration (Conrad, 1865, pl. 20, fig. 4) shows small denticulations on the inner side of the outer lip, which can be seen faintly in the specimens figured by

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PLATE 11

Figures — Page

1. *Hexaplex texanus* Vokes (X 4) 71
   PRI 3000 (holotype); height 13 mm, diameter 7 mm.
   Locality: Smithville, Bastrop County, Texas (= TU 243); Weches Formation.
2, 3. *Hexaplex vanuxemi* (Conrad) (X 2 1/2) 71
   2. USNM 450383; height 19.2 mm, diameter (including spine) 13.5 mm.
      Locality: TU 1511, Louisiana; Cook Mountain Formation.
   3. USNM 450384; height 17.5 mm, diameter (including spine) 12.2 mm.
      Locality: TU 86, Mississippi; Cook Mountain Formation.
4. *Hexaplex katherinae* Vokes (X 2) 74
   James Allen Collection; height 27 mm, diameter 19 mm.
   Locality: TU 99, Louisiana; Moodys Branch Formation.
5, 6. *Hexaplex engonatus* (Conrad) 74
   5. (X 1 1/4) USNM 645608; height 42.3 mm, diameter 26.6 mm.
      Locality: Allen's Branch, Sowtilpa Creek, Clarke Co., Alabama; Gosport Sand.
   6. (X 1 1/2) Alabama Geol. Surv. no. 72 (holotype – *Murex gosportensis* Aldrich *in* Palmer); height 32 mm, diameter 17 mm.
      Locality: Claiborne, Monroe Co., Alabama; Gosport Sand.
7, 8. *Hexaplex marksi* (Harris) (X 2) 75
   7. USNM 645609; height 26 mm, diameter 17 mm.
      Locality: TU 99, Louisiana; Moodys Branch Formation.
   8. James Allen Collection; height 24.5 mm, diameter 15 mm.
      Locality: TU 99, Louisiana; Moodys Branch Formation.
9. *Hexaplex supernus* (Palmer) (X 2 1/2) 75
   USNM 645610; height 20 mm, diameter 11 mm.
   Locality: Danville Landing, Ouachita River, Catahoula Parish, Louisiana; Danville Landing Member, Yazoo Formation.
10. *Hexaplex colei* (Palmer) (X 2) 75
   PRI 3002 (holotype); height 23 mm, diameter 13.5 mm.
   Locality: Orangeburg, Orangeburg County, South Carolina (= TU 354); McBean Formation.
11. *Hexaplex veatchi* (Maury) (X 1 1/2) 75
   USNM 645611; height 30 mm, diameter 18.5 mm.
   Locality: TU 951, Florida; Chipola Formation.

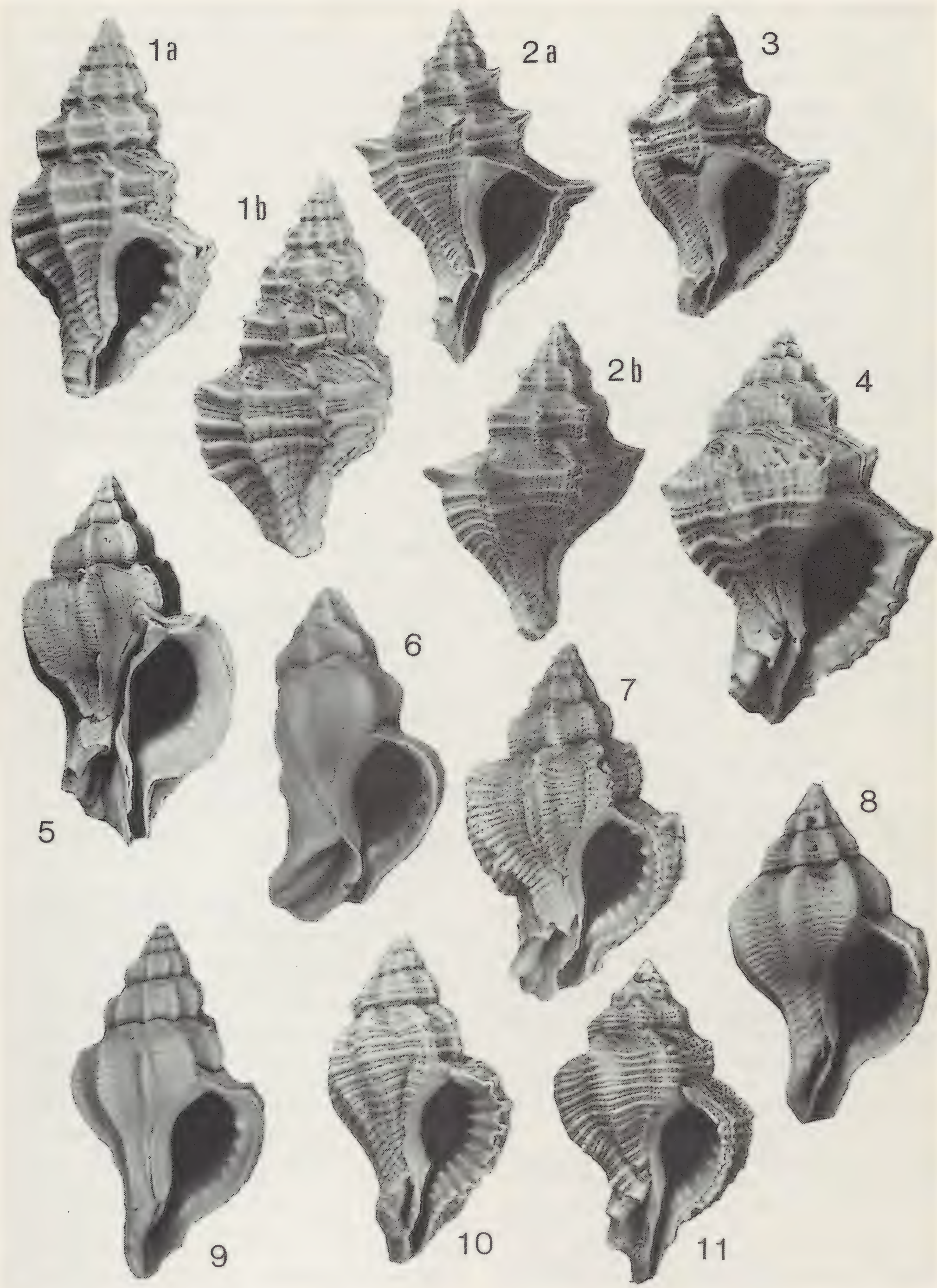

PLATE 11

Dockery (1980, pl. 35, figs. 2, 3). They are not present on either the specimen figured by Palmer (1937, pl. 35, fig. 9) or by Vokes (1968b, pl. 1, fig. 3a); therefore, a specimen with well developed denticulations (although otherwise rather poor) is figured here (pl. 11, fig. 3). All three species of the *H. texanus–H. vanuxemi–H. katherinae* complex have the same pattern of denticulations on the inside of the outer lip. It is the presence of denticulations on the columellar lip that distinguishes *H. texanus* from the other two.

In 1834 Conrad named another species from Claiborne, Alabama as *Murex septemnarius*. Both Palmer (1937, p. 269) and Moore (1962, p. 95) have noted that the holotype is lost and the species was never figured by Conrad. His description reads much like *H. vanuxemi:* "seven varices, and prominent subscabrous striae, with a fine line between; shoulder with prominent, acute, foliated spines". However, the size ("one inch") is slightly larger than any known specimen of *H. vanuxemi*. Should *M. septemnarius* ever be shown to be *H. vanuxemi,* it would be the prior name by almost 30 years. Although Conrad mentioned *Murex vanuxemi* in a list in 1834, he did not actually describe the species until 1865.

HEXAPLEX KATHERINAE Vokes
Plate 11, figure 4

Hexaplex (Hexaplex) katherinae VOKES, 1968, Tulane Stud. Geol., v. 6, no. 3, p. 100, pl. 1, fig. 4; DOCKERY, 1977, Mississippi Geol. Surv., Bull. 120, p. 67.

Holotype: Paleont. Resh. Inst., PRI 4648; height 21 mm, diameter 14.3 mm.

Type locality: Moodys Branch Formation; Town Creek, Jackson, Hinds County, Mississippi (= TU 917).

Occurrence: Moodys Branch Formation and Danville Landing member, Yazoo Formation, Mississippi and Louisiana.

Figured specimen: James Allen Collection; height 27 mm, diameter 19 mm; locality TU 99. Additional localities: TU 544, 1173.

Discussion: The Late Eocene species *H. katherinae* is clearly the descendant of *H. vanuxemi* but has a larger, more massive, more coarsely ornamented shell. Although described from the Moodys Branch Formation at Jackson, Mississippi (= TU 917) we have not collected it there, nor at Montgomery Landing, on the Red River, Grant Parish (TU 99). However, James Allen, of Alexandria, Louisiana, permitted me to photograph his excellent specimen from Montgomery Landing (pl. 11, fig. 4). In addition to the type locality in Mississippi, Dockery (1977, p. 25; after Harris and Palmer, 1947, p. 339) has reported *H. katherinae* from two localities in Caldwell Parish, Louisiana: Bunker Hill (= TU 544, where we also have it); and Gibson Landing, on the Ouachita River. We have the species from the Danville Landing member of the Yazoo Formation, near Bunker Hill, also in Caldwell Parish (TU 1173).

HEXAPLEX ENGONATUS (Conrad)
Plate 11, figures 5, 6

Hexaplex (Hexaplex) engonatus (Conrad). VOKES, 1968, Tulane Stud. Geol., v. 6, no. 3, p. 97, pl. 2, fig. 1; VOKES, 1970, Tulane Stud. Geol. Paleont, v. 8, no. 1, p. 51; DOCKERY, 1980, Mississippi Bur. Geol., Bull. 122, p. 99, pl. 35, fig. 4.

Synonym:

Murex gosportensis ALDRICH *in* PALMER, 1937, Bulls. Amer. Paleontology, v. 7, no. 32, p. 268, pl. 36, fig. 3; PALMER and BRANN, 1966, Bulls. Amer. Paleontology, v. 48, no. 218, p. 782.

Holotype: Acad. Nat. Sci. Philadelphia, ANSP 31386 (missing).

Type locality: (?)Gosport Sand, Claiborne Bluff, Monroe County, Alabama.

Occurrence: Cook Mountain Formation, Louisiana, Mississippi (= Wautubbee Formation); (?)Lisbon Formation and Gosport Sand, Alabama.

Figured specimens: Fig. 5, USNM 645608; height 42.3 mm, diameter 26.6 mm; locality, Allen's Branch, Sowtilpa Creek, Clarke Co., Alabama. Fig. 6, Alabama Geol. Surv. no. 72 (holotype – *Murex gosportensis);* height 32 mm, diameter 17 mm; locality, Claiborne, Alabama.

Discussion: Originally (Vokes, 1968b, p. 98), I observed that, although *H. engonatus* was described from "Claiborne, Alabama," we had never collected any specimens in the Gosport Sand, either at Claiborne Bluff (TU 78) or at Little Stave Creek (TU 306), another famous Gosport locality. In a subsequent note (Vokes, 1970b, p. 51), I reported that Dr. Henryk B. Stenzel, an authority on the Eocene of Texas, suggested that the type might have come from the Lisbon Formation, exposed

below the Gosport Sand at Claiborne Bluff (= localities TU 285, 424).

However, the holotype of *Murex gosportensis* Aldrich, named from the "Gosport Sand, Claiborne, Ala. Eocene" (Palmer, 1937, p. 268), is almost certainly a worn example of *H. engonatus* (compare pl. 11, figs. 5 and 6) and a beautiful specimen is here figured (pl. 11, fig. 5) from the Gosport Sand at Sowtilpa Creek, Clarke County, Alabama (U.S. National Museum collection).

The species is relatively common in the Cook Mountain (= Wautubbee Formation) of Mississippi. Dockery (1980, pl. 35, fig. 4) has figured a peculiar example that appears to be pathologic, with only four varices on the body whorl, instead of the normal five or six.

HEXAPLEX MARKSI (Harris)
Plate 11, figures 7, 8

Hexaplex (Hexaplex) marksi (Harris). VOKES, 1968, Tulane Stud. Geol., v. 6, no. 3, p. 98, pl. 2, fig. 3; DOCKERY, 1977, Mississippi Geol. Surv, Bull. 120, p. 67, pl. 9, figs. 6, 8; DOCKERY, 1980, Mississippi Bur. Geol., Bull. 122, p. 99, pl. 58, fig. 8.

Holotype: USNM 135148; height 23.5 mm, diameter 15 mm.

Type locality: Whites Bluff Formation; one mi northeast (in a well) of Pansy Post Office, Cleveland County, Arkansas.

Occurrence: Moodys Branch Formation, Louisiana and Mississippi; Whites Bluff Formation, Arkansas.

Figured specimens: Fig. 7, USNM 645609; height 26 mm, diameter 17 mm; locality TU 99. Fig. 8, James Allen Collection; height 24.5 mm, diameter 15 mm; locality TU 99.

Discussion: In addition to the type locality in Arkansas, and the two localities I originally reported (TU 99, 917: Vokes, 1968b, p. 98), Dockery (1977, p. 67; 1980, p. 100; both after Harris and Palmer, 1947, p. 341) has reported this species from three other localities in Louisiana: Bunker Hill (= TU 544) and Gibsons Landing, in Caldwell Parish [his no. P118 is an error for P1118]; and Montgomery Landing, Grant Parish (= TU 99).

In this variable species, some specimens have expanded varices and others, at the same locality, have only rounded ribs (compare pl. 11, figs. 7 and 8). The same variation is present in the older *H. engonatus*, which led to the unnecessary synonym, *Murex gosportensis* Aldrich.

HEXAPLEX SUPERNUS (Palmer)
Plate 11, figure 9

Hexaplex (Hexaplex) supernus (Palmer). VOKES, 1968, Tulane Stud. Geol., v. 6, no. 3, p. 100, pl. 2, fig. 2; DOCKERY, 1977, Mississippi Geol. Surv., Bull. 120, p. 67.

Holotype: Paleont. Resh. Inst., PRI 4653; height 20.5 mm, diameter 11 mm. Type locality: Moodys Branch Formation; Bayou Toro, Vernon Parish, Louisiana (= TU 545).

Occurrence: Moodys Branch Formation (upper beds) and Danville Landing Member, Yazoo Formation, Louisiana and Mississippi.

Figured specimen: USNM 645610; height 20 mm, diameter 11 mm; locality, Danville Landing, Ouachita River, Catahoula Parish, Louisiana. Additional localities: TU 1099, 1173.

Discussion: Hexaplex supernus is the youngest member of the species complex *H. engonatus–H. marksi–H. supernus*. It is most common in the Danville Landing beds, now considered to be the uppermost member of the Yazoo Formation, Jackson Group, according to Dockery (1980, p. 22).

HEXAPLEX COLEI (Palmer)
Plate 11, figure 10

Hexaplex (Hexaplex) colei (Palmer). VOKES, 1968, Tulane Stud. Geol., v. 6, no. 3, p. 96, pl. 2, fig. 4.

Holotype: Paleont. Resh. Inst., PRI 3002; height 23 mm, diameter 13.5 mm.

Type locality: McBean Formation, about 3 mi WNW of Orangeburg, Orangeburg County, South Carolina (= TU 354).

Occurrence: McBean Formation, South Carolina; Weches Formation and Stone City Beds, Texas.

Figured specimen: PRI 3002 (holotype).

Discussion: The Middle Eocene species, *H. colei*, is more closely related to the Early Miocene Chipola species *H. veatchi* than to any other known Eocene species.

HEXAPLEX VEATCHI (Maury)
Plate 11, figure 11

Hexaplex (Hexaplex) veatchi (Maury). VOKES, 1968, Tulane Stud. Geol., v. 6, no. 3, p. 101, pl. 3, figs. 3, 5; VOKES, 1972, Earth Sci., v. 25, no. 3, p. 122, pl. 1, fig. 10.

Lectotype: Paleont. Resh. Inst., PRI 3462 (designated by Brann and Kent, 1960, p. 573); height 21 mm, diameter 13 mm.

Type locality: Chipola Formation; "Bailey's Ferry, Florida" = TU 554, east bank of Chipola River, at power line crossing (SW 1/4 Sec. 17, T1N, R9W), Calhoun County, Florida (designated by Vokes, 1968b, p. 101).

Occurrence: Tampa Limestone and Chipola Formation, Florida.

Figured specimen: USNM 645611; height 30 mm, diameter 18.5 mm; locality TU 951. Additional localities: TU 458, 459, 546, 548, 555, 950, 998, 999, 1048, 1196.

Discussion: The unusual species *H. veatchi* is never common, but it occurs rarely at almost every locality in the Chipola Formation and in every facies, on Tenmile Creek, on Farley Creek, and on the Chipola River.

HEXAPLEX ISTHMICUS Vokes, n. sp.
Plate 12, figure 3

Description: Shell with six teleoconch whorls preserved, protoconch and earliest teleoconch whorls not preserved. Spiral ornamentation on earliest whorls of many fine threads. On body whorl five broad raised welts, with between each pair one thin sharp spiral cord, also five in number; entire shell surface covered by shagreened tertiary threads. Axial ornamentation on each whorl of five or six rounded varices; between each pair one sharply defined intervarical ridge; where spiral welts and cords cross varices, short open spines produced; those at the welts larger, at the cords smaller in size. Suture markedly appressed, giving almost no definition to the individual whorls but forming a deep angular anal notch. Aperture elongate-oval. Inner lip narrow, smooth, appressed along entire length. Margin of outer lip crenulated by sharp forward-directed projections, corresponding to the spaces between the spines, both major and minor; smooth on the inner side. Nature of siphonal canal unknown but assumed to be broad, moderately long, and recurved at the distal end.

Holotype: USNM 450386; height (incomplete) 51.9 mm, diameter 44.1 mm.

Type locality: TU 1433, Gatun Formation; north side of Boyd-Roosevelt Highway, clearing behind Urbanization San Martin, approximately 0.5 km east of junction of road to Refinería Panamá, S.A., at Cativá, Prov. of Colón, Panama.

Etymology of name: *isthmus* (L.) = narrow neck of land, referring to type locality in Isthmus of Panama.

Occurrence: Gatun Formation, Panama.

Figured specimen: USNM 450386 (holotype).

Discussion: This new species, represented by a single incomplete specimen, is so distinctive that I have no hesitation in describing it. Superficially similar to *H. etheringtoni,* from the Tubará Group (see below), it is readily distinguished by the presence of the strong intervarical ridges not present in the Colombian shell, and by the appressed suture, which gives it a biconic appearance. Other than *H. etheringtoni,* there is no species, fossil or Recent, with which this this unusual form may be compared.

PLATE 12

Figures Page

1. *Hexaplex etheringtoni* Vokes (X 1 1/4) 78
   UCMP 33837 (holotype); height 62 mm, diameter (incomplete) 32 mm.
   Locality: UCMP S-66, Punta Pua, Colombia; Tubará Group.
2. *Hexaplex hertweckorum* (Petuch) (X 1) 78
   USNM 645613; height 64 mm, diameter 43.5 mm.
   Locality: TU 797, Florida; Pinecrest Beds.
3. *Hexaplex isthmicus* Vokes, n. sp. (X 1 1/4) 76
   USNM 450386 (holotype); height (incomplete) 51.9 mm, diameter 44.1 mm.
   Locality: TU 1433, Panama; Gatun Formation.
4. *Hexaplex fulvescens* (Sowerby) (X 1) 78
   USNM 678100; height 81 mm, diameter 63.5 mm.
   Locality: TU R-60, off Florida; Recent.

5, 6. *Murex williamsi* Maury (X 2) 6
   5. Mus. Nacl. Rio de Janiero, DNPM 556 (holotype); height 29.4 mm; diameter 15.3 mm.
      Locality: Rio Pirabas, Para, Brazil; Pirabas Limestone.
   6. Maury, 1925, pl. 6, fig. 8.

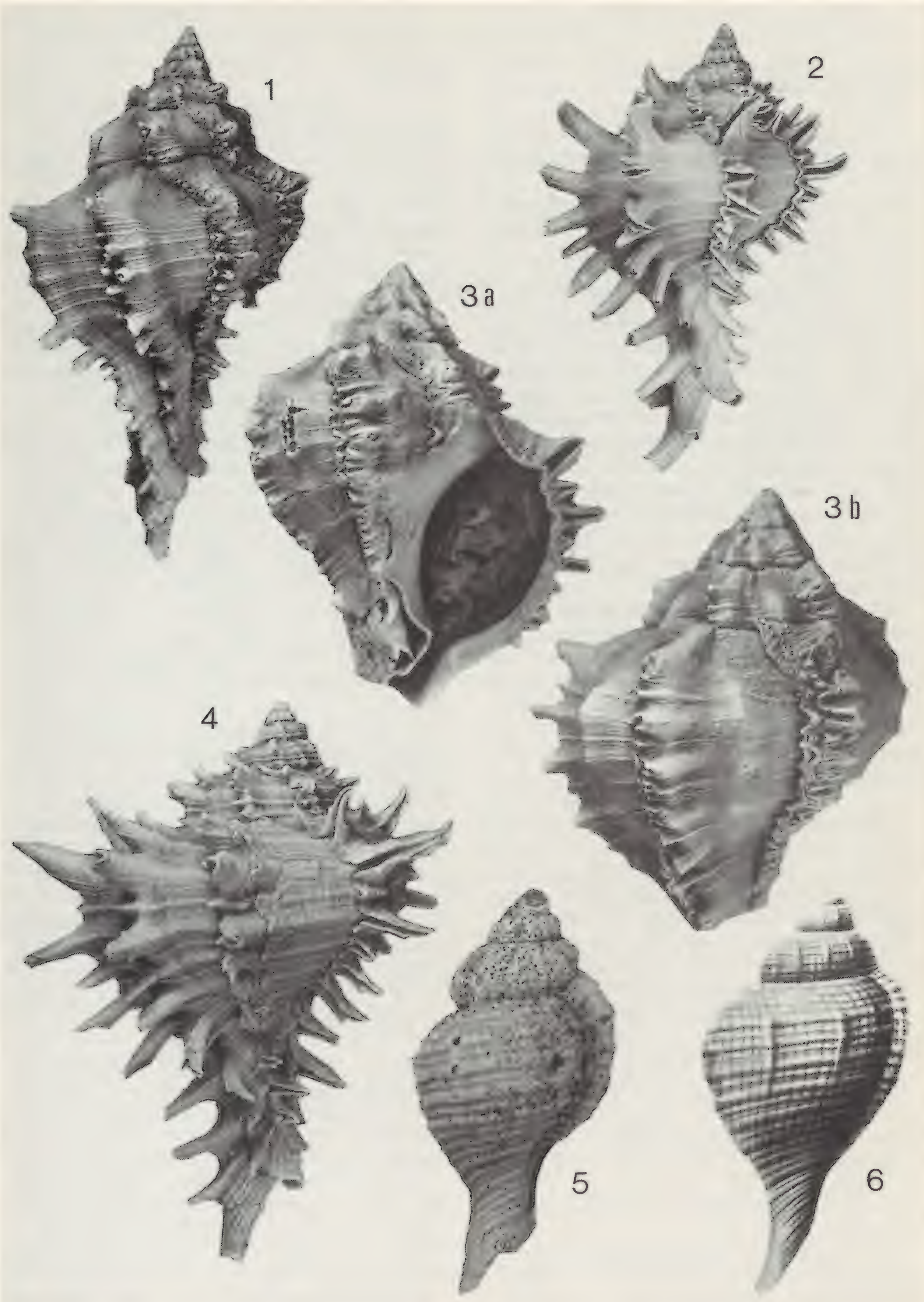

PLATE 12

HEXAPLEX ETHERINGTONI Vokes
Plate 12, figure 1

Hexaplex (Hexaplex) etheringtoni VOKES, 1968, Tulane Stud. Geol., v. 6, no. 3, p. 102, pl. 4, fig. 2.

Holotype: Museum of Paleontology, University of California, Berkeley, UCMP 33837; height 62 mm, diameter (incomplete) 32 mm.

Type locality: UCMP S-66, Tubará Group; Punta Pua, about 15 mi (24 km) northeast of Cartegena, Depto. de Bolívar, Colombia.

Occurrence: Tubará Group, Colombia.

Figured specimen: UCMP 33837 (holotype).

Discussion: This unique specimen from the Tubará Group is now considered to be Pliocene or even Pleistocene in age rather than Late Miocene, as when the species was described. At the same locality (UCMP S-66) there are specimens of *Haustellum olssoni* (Vokes), described from the Moín Formation, and *Dermomurex alabastrum* (A. Adams, 1864) otherwise known only from the Recent fauna. Thus, the probability of a Pleistocene age is strongly indicated.

Otherwise, there is nothing to add to the original discussion. Of interest, however, is the discovery of *H. isthmicus,* n. sp., a similar form from the Gatun Formation of Panama, described above, more closely related to this species than to any other. It is presumed to be ancestral to *H. etheringtoni.*

HEXAPLEX HERTWECKORUM (Petuch)
Plate 12, figure 2

Muricanthus ambiguus (Reeve). OLSSON, 1964, Neogene Moll. Northwest. Ecuador, p. 138, pl. 29, fig. 5 (not of Reeve); VOKES, 1968, Tulane Stud. Geol., v. 6, no. 3, p. 87.

Hexaplex (Hexaplex) fulvescens (Sowerby). VOKES, 1968, Tulane Stud. Geol., v. 6, no. 3, p. 104 [in part, not of Sowerby], pl. 3, fig. 1, pl. 4, figs. 1, 3 only.

Muricanthus hertweckorum PETUCH, 1988, Bull. Paleomalac., v. 1, no. 1, p. 18, pl. 3, figs. 1-3; PETUCH, 1988, Neogene History Trop. Amer. Moll., pl. 12, figs. 1, 2, pl. 17, fig. 6.

Hexaplex hertweckorum (Petuch). VOKES, 1988, Tulane Stud. Geol. Paleont., v. 21, no. 1, p. 24, pl. 1, figs. 7, 8.

Holotype: USNM 424261; height 40 mm, diameter 35 mm.

Type locality: APAC Pit (Macasphalt Pit # 0800826), Sarasota, Sarasota County, Florida (= TU 1000).

Occurrence: Esmeraldas Beds, Ecuador; Pinecrest Beds, Florida.

Figured specimen: USNM 645613; height 64 mm, diameter 43.5 mm; locality TU 797. Additional localities: TU 728, 729, 730, 769, 796, 933, 1000, 1493.

Discussion: Originally (Vokes, 1968b, p. 104), I considered this species as the living *H. fulvescens.* With the discovery of numbers of specimens at Sarasota, Florida (TU 1000) it became clear that the two forms are not the same. A new name was proposed by Petuch, who noted that the Pliocene form differs from the Recent in "having a thinner, more inflated shell with a distinctly rounded shoulder, by having more ornate, recurved varical spines, and by having finer, less developed spiral cords on the intervarical areas" (1988a, p. 20).

The shell that Olsson (1964, p. 138, pl. 29, fig. 5) reported from the Esmeraldas Beds of Ecuador as "*Muricanthus ambiguus* (Reeve)" is the same as *H. hertweckorum,* and is among the four muricid species that occur in both the Esmeraldas and the Pinecrest beds (Vokes, 1988, p. 9).

In the Esmeraldas study, it was noted that *H. hertweckorum* is more closely related to the West African *H. duplex* (Röding, 1798) than to *H. fulvescens;* the sole difference being the lack of a small secondary spine between the shoulder spine and the suture in the African species (compare Vokes, 1988, pl. 1, figs. 7 and 9). As the Pliocene members of *Hexaplex* in the western Atlantic differ so strikingly from the older species, it is assumed that this group originated in West Africa and migrated via northern South America, through the Bolivar Trough to the eastern Pacific. In the process some individuals made their way north to Florida.

HEXAPLEX FULVESCENS (Sowerby)
Plate 12, figure 4

Hexaplex (Hexaplex) fulvescens (Sowerby). VOKES, 1968, Tulane Stud. Geol., v. 6, no. 3, p. 104 [in part, not Pinecrest localities], pl. 3, fig. 4, pl. 4, fig. 4 only.

Muricanthus fulvescens (Sowerby). RADWIN and D'ATTILIO, 1976, Murex Shells of the World, p. 76, pl. 12, fig. 3; PETUCH, 1988, Bull. Paleomalac., v. 1, no. 1, p. 20.

Hexaplex fulvescens (Sowerby). FAIR, 1976, The Murex Book, p. 4, pl. 12, fig. 143.

Holotype: Not found.

Type locality: South Carolina (designated by Kiener, 1843, p. 50, for *Murex spinicosta* Valen-

ciennes, a synonym).

Occurrence: Unnamed Pleistocene formations, Louisiana, Florida, South Carolina. Recent, southeastern U. S., from North Carolina to Texas and northern Yucatán Peninsula.

Figured specimen: USNM 678100; height 81 mm, diameter 63.5 mm; locality TU R-60. Additional fossil localities: TU 1, 578, 977.

Discussion: In 1968 there was but a handful of "Miocene" (*i.e.*, Pinecrest Beds) specimens of *Hexaplex* known from southern Florida. These I placed in the Recent species *H. fulvescens,* stating that the species occurred at "several different Miocene localities in the vicinity of Lake Okeechobee" but had not been taken at any Pliocene (*i.e.*, Caloosahatchee Formation) localities (Vokes, 1968b, p. 104). With the discovery of hundreds of specimens in the excavations near Sarasota, Florida (TU 1000), I recognized the fossil species as new. But my statement about the Pliocene beds is still relevant: neither *H. hertweckorum* (Petuch, 1988), as the Pinecrest species was subsequently named, nor *H. fulvescens* has been taken in the Caloosahatchee or Bermont formations (unless locality TU 578, in St. Lucie County, should be placed in one of these units).

The fossiliferous beds in the general vicinity of St. Lucie County have been placed in the Pamlico Formation of Late Pleistocene age. However, the fauna at TU 578 is unlike any other locality that we have collected in the area. There are numerous specimens of an arcacean pelecypod that is indistinguishable from the North Carolina species *Noetia (Eontia) limula* (Conrad, 1832) (see Blackwelder, 1981, pl. 8, fig. 5, for a good illustration). According to MacNeil (1937, p. 19) this species is restricted to the "Croatan Sand" (= James City Formation), a time equivalent of the Waccamaw Formation of North and South Carolina and the Caloosahatchee Formation of Florida. MacNeil (1937, p. 21) noted that in the U. S. Geological Survey collections from Fellsmere, St. Lucie County [Indian River County], and other localities in eastern Florida, there are specimens that "appear to be closely related to *E. limula*" and he illustrates one from Volusia County (USNM 496526) as *Eontia* cf. *E. variabilis* MacNeil (1937, pl. 2, fig. 16) that appears to be the same as ours from TU 578. Occurring with these unexpected northern *Eontia* specimens are also several examples of *Busycon carica* (Gmelin, 1791), which today occurs from Cape Cod to Cape Canaveral, Florida (Abbott, 1974, p. 222), and in the fossil record from the Late Pliocene to the Recent (Blackwelder, 1981, p. 4).

Are these beds in St. Lucie, Indian River, Brevard, and Volusia counties the time equivalent of the more northern James City Formation? This seems unlikely, as the correlative Caloosahatchee and Waccamaw formations surrounding this anomalous fauna are obviously representative of much warmer water. A more likely explanation is that this northern fauna moved south during the period of cooler water that caused the demise of the Waccamaw and Caloosatatchee faunas. This cool-water fauna is probably the same age as the Late Pleistocene beds in South Carolina, from whence Holmes (1860, pl. 10, fig. 2) figured a similar specimen of *H. fulvescens* (as *Murex spinicostatas* [*sic*]). Olsson and Harbison (1953, p. 7) report large numbers of specimens of *H. fulvescens* taken in the Pleistocene beds near Largo, Pinellas County.

Thus, *H. fulvescens* is known only in the Late Pleistocene and Recent faunas. Its range is extremely limited in the Recent fauna, but it is abundant within that small area. Wells (1958) described the eating habits of the species, which opens oysters with the outer lip but drills clams and mussels. This flexibility permits an individual to consume 3.5 clams/week.

In 1968, I included (with a query) the species described from "Santo Domingo" as *Murex pudicus* Reeve, 1845, in the synonymy of *H. fulvescens*. Later, Kaicher (1980, no. 2504) figured the type (BMNH 197498), which is a West African species with only a generic similarity to *H. fulvescens*.

HEXAPLEX STRAUSI (Verrill)

Hexaplex (Hexaplex) strausi (Verrill). VOKES, 1968, Tulane Stud. Geol., v. 6, no. 3, p. 105.

Hexaplex strausi (Verrill). FAIR, 1976, The Murex Book, p. 79, text-fig. 59 (after Verrill); SUTTY, 1986, Seashell Treasures of the Caribbean, p. 57, text-fig. 57; VOKES, 1988, Tulane Stud. Geol. Paleont., v. 21, no. 1, p. 24 (as ? = *H. radix*).

Holotype: Not found; height 50-59 mm, diameter 36-40 mm (*fide* Verrill, 1950c, p. 5; larger specimen illustrated is probably 59 mm).

Type locality: Dominica, Lesser Antilles.

Occurrence: Recent only, Lesser Antilles.

Discussion: The species described by Verrill (1950c, p. 4) as *Murex (Aaronia) strausi* was so similar to *H. radix* (Gmelin, 1791) that it was universally ignored until 1986 when Sutty reported two more examples off Martinique. Verrill's specimens ("three adult and two young shells") were said to have been taken (?alive, illustrations show opercula in place) in a fish trap at 75 to 100 fathoms (= 137-183 meters), considerably deeper than members of this group ordinarily live. This did not help in the acceptance of his species. However, Sutty's specimens were alive and came from 6.4 meters (21 ft), a more realistic depth. This causes wonder as to why no one else has taken any specimens of the species. Unlike Verrill's crude drawings, Sutty's color photographs (1986, text-fig. 57) are excellent – but the shells still look to me like juvenile specimens of *H. radix!* There may be a colony of *H. radix* established in the Lesser Antilles, but I cannot help but believe that they have been introduced in some fashion.

VI. LOCALITY DATA

The following are Tulane University fossil locality numbers:

1. Unnamed formation, material dredged from depth of 15 to 30 feet for construction of Interstate 10, south of Lake Pontchartrain, between Downman Road and Paris Road, New Orleans, Orleans Parish, Louisiana.

60. Jackson Bluff Fm., borrow pits at Jackson Bluff, Ochlockonee River (NW 1/4 Sec. 21, T1S, R4W), Leon Co., Florida.

61. Stone City Beds, type locality, Stone City Bluff on Brazos River, at crossing of bridge of Texas Highway 21, Burleson Co., Texas.

69. Shoal River Fm., type locality, Shell Bluff, Shoal River (NW 1/4 Sec. 4, T3N, R21W), about 3 1/2 miles north of Mossyhead, Walton Co., Florida.

69A. Shoal River Fm., first ravine upstream from Shell Bluff, Shoal River (NW 1/4 Sec. 4, T3N, R21W), about 3 1/2 miles north of Mossyhead, Walton Co., Florida.

70. Chipola Fm., Tenmile Creek, at bridge of Florida Highway 73 (NW 1/4 Sec. 12, T1N, R10W), Calhoun Co., Florida.

76. Mint Springs Fm., type locality, Mint Springs Bayou, just off U.S. Highway 61 (Business), at Vicksburg Natl. Military Cemetery, Vicksburg, Warren Co., Mississippi.

78. Gosport Sand, Claiborne Bluff, east bank of Alabama River, south of bridge of U.S. Highway 84, Monroe Co., Alabama.

79. Caloosahatchee Fm. and Bermont Fm. mixed, spoil banks north and south side of Caloosahatchee River, at Ortona Lock (Sec. 27, T42S, R30E), Glades Co., Florida.

86. Wautubbee Fm.[= Cook Mountain Fm.], roadcut on east side on Mississippi Highway 15, 0.8 mile north of junction with U. S. Highway 80, Newton Co., Mississippi. (Note: Interstate 20 has subsequently covered this locality and it is no longer available.)

91. Oak Grove Sand, type locality, west bank of Yellow River, about 100 yards below bridge at Oak Grove (NE 1/4 Sec. 20, T5N, R23W), Okaloosa Co., Florida.

99. Moodys Branch Fm., Montgomery Landing (also known as Creola Bluff), west bank of Red River (Sec. 20, T8N, R5W), Grant Parish, Louisiana.

196. Chipola Fm., Tenmile Creek, about 1/4 mile upstream from bridge of Florida Highway 73 (NE 1/4 Sec. 11, T1N, R10W), Calhoun Co., Florida.

201. Bermont Fm., spoil banks at pit just south of Belle Glade (at Belle Glade Camp), Palm Beach Co., Florida.

226. Red Bluff Fm., west bank Chickasawhay River, approximately one mile southwest of Hiwannee (SW 1/4 Sec. 28, T10N, R7W), Wayne Co., Mississippi.

243. Weches Fm., Colorado River, 625 feet downstream from bridge of Texas Highway 71 at Smithville, Bastrop Co., Texas.

283. Caloosahatchee Fm. and Bermont Fm. mixed, spoil banks on cross-canal 1.3 miles southwest of Port Charlotte Railroad Station (formerly Murdock), on south side of Florida Highway 771 and Seaboard Air Line Railroad (Sec. 12, T40S, R21E), Charlotte Co., Florida.

285. Lisbon Fm., Claiborne, east bank of Alabama River, below bridge of U. S. Highway 84, lowest water level, Monroe Co., Alabama.

306. Gosport Sand, Little Stave Creek, northeast of Jackson, Clarke Co., Alabama.

354. McBean Fm., roadcut on U.S. Highway 21, 1.9 miles north of junction with U.S. Highway 178 Bypass, at Orangeburg, Orangeburg Co., South Carolina.

424. Lisbon Fm., Claiborne, east bank Alabama River, below bridge of U. S. Highway 84 (same as TU 285 but bed immediately above; locality is on sloping beach down-

stream from bridge at low water, while TU 285 is at very edge of river channel almost under the bridge), Monroe Co., Alabama.

453. Chipola Fm., Alum Bluff (lower beds), Apalachicola River (NE 1/4 Sec. 24, T1N, R8W), Liberty Co., Florida.

456. Chipola Fm., Tenmile Creek, about 1/4 mile downstream from bridge of Florida Highway 73 (NW 1/4 Sec. 12, T1N, R10W), Calhoun Co., Florida.

457. Chipola Fm., west bank of Chipola River, about 1/2 mile below Tenmile Creek (SW 1/4 Sec. 17, T1N, R9W), Calhoun Co., Florida. (Same as USGS 2213, 2564, and 3419, "one mile below Bailey's ferry.")

458. Chipola Fm., east bank of Chipola River, above Farley Creek (SW 1/4 Sec. 20, T1N, R9W), Calhoun Co., Florida.

459. Chipola Fm., east bank of Chipola River, steep bank about 1500 feet above the mouth of Taylor Lake Branch (NW 1/4 Sec. 29, T1N, R9W), Calhoun Co., Florida.

520. Pinecrest Beds, spoil banks, canal 0.9 mile east of Brighton on Florida Highway 70 (Sec. 25, T37S, R32E), Highlands Co., Florida.

531. Caloosahatchee Fm., spoil banks on cross-canal 1.3 miles southwest of Port Charlotte Railroad Station (formerly Murdock), on north side of Florida Highway 771 and Seaboard Air Line Railroad (Sec. 12, T40S, R21E), Charlotte Co., Florida.

536. Caloosahatchee Fm., south bank of Caloosahatchee River about one mile east of La Belle (Sec. 3 & 4, T43S, R29E), Hendry Co., Florida. (Designated as type locality of the Caloosahatchee Formation by Olsson *in* Olsson and Petit, 1964, p. 519.)

539A. Bermont Fm., Shell Creek (upper beds), about 8 miles east of Cleveland (Sec. 30, T40S, R25E), Charlotte Co., Florida. (Designated as type locality of the Bermont Formation by DuBar, 1974, p. 221.)

539B. Caloosahatchee Fm., Shell Creek (lower beds), about 8 miles east of Cleveland (Sec. 30, T40S, R25E), Charlotte Co., Florida.

544. Moodys Branch Fm., Bunker Hill, on south side of Ouachita River (N 1/2, Sec. 24, T12N, R4E), about 8 miles southeast of Columbia, Caldwell Parish, Louisiana.

545. Moodys Branch Fm., east bank of Bayou Toro (NW 1/4 Sec. 6, T3N, R11W), Vernon Parish, Louisiana.

546. Chipola Fm., Tenmile Creek, about 1 3/4 miles west of Chipola River (NE 1/4 Sec. 12, T1N, R10W), Calhoun Co., Florida (= USGS 2212, "one mile west of Bailey's Ferry").

547. Chipola Fm., west bank of Chipola River, about 2000 feet above Fourmile Creek (SW 1/4 Sec. 29, T1N, R9W), Calhoun Co., Florida.

548. Chipola Fm., west bank of Chipola River, at bend about 1800 feet south of mouth of Farley Creek (NW 1/4 Sec. 29, T1N, R9W), Calhoun Co., Florida.

549. Chipola Fm., east bank of Chipola River, about 1/4 mile below Fourmile Creek (NE 1/4 Sec. 32, T1N, R9W), Calhoun Co., Florida.

552. Chipola Fm., east bank of Chipola River, about 1 1/2 miles below Tenmile Creek (NE 1/4 Sec. 20, T1N, R9W), Calhoun Co., Florida.

553. Chipola Fm., mouth of Farley Creek, at Chipola River (SW 1/4 Sec. 20, T1N, R9W), Calhoun Co., Florida.

554. Chipola Fm., east bank of Chipola River at power line crossing (SW 1/4 Sec. 17, T1N, R9W), Calhoun Co., Florida.

555. Chipola Fm., east bank of Chipola River, about 1000 feet above Fourmile Creek (SW 1/4 Sec. 29, T1N, R9W), Calhoun Co., Florida.

558. Waccamaw Fm., borrow pits at north end of Crescent Beach Airport, Crescent Beach, Horry Co., South Carolina.

559. Waccamaw Fm., "Neill's Eddy Landing", south bank of Cape Fear River near Acme, Columbus Co., North Carolina.

562. Silverdale Beds, Onslow County marl pit on south side of Webb Creek, near Silverdale, Onslow Co., North Carolina.

578. Unknown formation, "Rim Ditch" spoil banks, 1/2 mile south of Florida Highway 68 (Sec. 8, T35S, R38E), St. Lucie Co., Florida.

579. Caloosahatchee Fm., Miami Canal spoil banks, 4 miles north of pumping station at Broward county line, Palm Beach Co., Florida.

580. Bermont Fm., North New River Canal spoil banks, one mile south of South Bay, Palm Beach Co., Florida.

583. Caloosahatchee Fm., Miami Canal spoil banks, 7 miles north of pumping station at Broward county line, Palm Beach Co., Florida.

589. Rio Banano Fm., Rio Banano, north bank, about 0.6 to 0.8 km above the railroad bridge at La Bomba, Limón Province, Costa Rica.

635. Encanto Fm., roadcut on Mexico Highway 185, 2.3 km south of bridge over Rio Jaltepec, at Oaxaca-Veracruz state line, Mexico.

638. Agueguexquite Fm., roadcut, pipeline cut, and quarry on Mexico Highway 180, 23 km east of junction with side road into Coatzacoalcos, Veracruz, Mexico.

642. Red Bluff Fm., Hiwannee, Chickasawhay River, about 1/2 mile upstream from loc. TU 226 (NE 1/4 Sec. 28, T10N, R7W), Wayne Co., Mississippi.

655. Chipola Fm., Tenmile Creek, about 0.1

mile downstream from bridge of Florida Highway 73 (NW 1/4 Sec. 12, T1N, R10W), Calhoun Co., Florida.

704. Silverdale Beds, Gillette's Marl Pits (old pit) 1/3 mile from junction of roads to Stella and Swansboro at Silverdale, Onslow Co., North Carolina.
705. Bowden Fm., type locality, Bowden, east of Port Morant, Parish of St. Thomas, Jamaica.
708. Chipola Fm., at small waterfall tributary to Tenmile Creek, south bank, about 1/4 mile downstream from bridge of Florida Highway 73 (NW 1/4 Sec. 12, T1N, R10W), Calhoun Co., Florida.
709. Chipola Fm., Tenmile Creek, about 1/4 mile downstream from bridge of Florida Highway 73 (NW 1/4 Sec. 12, T1N, R10W), Calhoun Co., Florida.
711. Chipola Fm., west bank of Chipola River, about 1/4 mile up from Farley Creek (SW 1/4 Sec. 20, T1N, R9W), Calhoun Co., Florida.
725. Bermont Fm., North New River Canal spoil banks, 3 miles south of South Bay, at Okeelanta, Palm Beach Co., Florida.
726. Caloosahatchee Fm., Hendry County rock pit, 1/2 mile north of Florida Highway 80, three miles west of La Belle (SE 1/4 Sec. 14, T43S, R28E), Hendry Co., Florida.
727. Bermont Fm., borrow pits 2.2 miles east of U.S. Highway 27, 15 miles south of South Bay, Palm Beach Co., Florida.
728. Pinecrest Beds, spoil banks on west side of Kissimmee Canal and east side of Kissimmee River, just across from U.S. Corps of Engineers Structure 65-D (Sec. 33, T36S, R33E), Okeechobee Co., Florida.
729. Pinecrest Beds, spoil banks on west side of Kissimmee Canal and east side of Kissimmee River, approximately 1/2 mile south of U.S. Corps of Engineers Structure 65-D (S 1/2 Sec. 33, T36S, R33E), Okeechobee Co., Florida.
730. Pinecrest Beds, embankment of Seaboard Air Line Railroad, just west of Kissimmee River (NW 1/4 Sec. 20, T36S, R33E), Highlands Co., Florida.
731. Bermont Fm., West Palm Beach Canal spoil banks, at Twenty Mile Bend Recreation area just east of junction of U.S. Highways 441 and 98, Palm Beach Co., Florida.
733. Bermont Fm., North New River Canal spoil banks, one mile north of Florida Highway 80, at South Bay, Palm Beach Co., Florida.
736. Pinecrest Beds and Caloosahatchee Fm. mixed, spoil banks on south side of Florida Highway 70 and east side of Kissimmee River, Okeechobee Co., Florida.
737. Pinecrest Beds, levee fill, L-28, 2.8 miles west of gate at U.S. Corps of Engineers Structure S-12A, at "Forty-Mile Bend," U.S. Highway 41, Dade Co., Florida.
740. Pinecrest Beds, levee fill, L-28, 3.6 miles west and 2.6 miles south of pumping station on Miami Canal at Broward-Palm Beach county line, Broward Co., Florida.
742. Pinecrest Beds, levee fill, L-28, 3.6 miles west and 5.6 miles south of pumping station on Miami Canal at Broward-Palm Beach county line, Broward Co., Florida.
743. Bermont Fm., spoil banks on drainage canal 7 miles east of U.S. Highway 27, 15 miles south of South Bay, Palm Beach Co., Florida.
746. Bermont Fm., North New River Canal spoil banks, 5.3 miles north of pumping station at Broward county line on U.S. Highway 27, Palm Beach Co., Florida.
747. Bermont Fm., North New River Canal spoil banks, 2 miles south of South Bay, Palm Beach Co., Florida.
748. Bermont Fm., Lake Okeechobee levee, 2 miles north of South Bay, Palm Beach Co., Florida.
750. Bermont Fm., spoil banks cross-canal 3.1 miles south of Lake Harbor on Miami Canal, Palm Beach Co., Florida.
751. Bermont Fm., North New River Canal spoil banks, 1 1/2 miles south of South Bay, Palm Beach Co., Florida.
752. Pinecrest Beds, spoil banks on south side of Canal 41-C ("Slough Ditch") at crossing of country road, 4.3 miles east of Brighton and 1.4 miles south of Florida Highway 70 (SE 1/4 Sec. 33, T37S, R33E), Highlands Co., Florida.
755. Caloosahatchee Fm., Miami Canal spoil banks, 17.4 miles north of pumping station at Broward county line, Palm Beach Co., Florida.
756. Pinecrest Beds, Port Charlotte Development, spoil banks west side of Elkcan Waterway, 2.3 miles southeast of Port Charlotte Railroad Station (formerly Murdock) and 1.7 miles east of U.S. Highway 41 (Sec. 10, T40S, R22E), Charlotte Co., Florida.
757. Gatun Fm., roadcut on south side of Boyd-Roosevelt Highway at junction of road to "Refinería Panamá, S.A.," just east of Cativá, Prov. of Colón, Panama.
759. Bermont Fm., spoil banks north side of Caloosahatchee River, 2 miles west of Ortona Lock (NE 1/4 Sec. 29, T42S, R30E), Glades Co., Florida.
767. Caloosahatchee Fm. and Bermont Fm. mixed, spoil banks north side of Caloosahatchee River, 5 miles west of Ortona Lock (NW 1/4 Sec. 36, T42S, R29E), Glades Co., Florida.
768. Caloosahatchee Fm. and Bermont Fm. mixed, spoil banks north side of

Caloosahatchee River, 5 1/2 miles west of Ortona Lock (NW 1/4 Sec. 35, T42S, R29E), Glades Co., Florida.

769. Pinecrest Beds, spoil banks east side of Kissimmee River, 1 1/2 to 2 miles south of U.S. Corps of Engineers Structure 65-D (NE 1/4 Sec. 35, T36S, R33E), Okeechobee Co., Florida.

770. Pinecrest Beds and Caloosahatchee Fm. mixed, spoil banks west side of Kissimmee River, 1 1/2 to 3 1/2 miles north of Florida Highway 70 (Secs. 10, 14, 15, and 28, T37S, R33E), Highlands Co., Florida.

786. Chipola Fm., Tenmile Creek, 1/4 mile upstream from bridge of Florida Highway 73 (NE 1/4 Sec. 11, T1N, R10W), Calhoun Co., Florida.

787. Chipola Fm., Tenmile Creek, about 1 1/2 miles west of Chipola River (SE 1/4 Sec. 12, T1N, R10W), Calhoun Co., Florida.

788. Pinecrest Beds and Bermont Fm. mixed, Port Charlotte Development, spoil banks at U-shaped canal on north side of Florida Highway 771, 3.4 miles southwest of U.S. Highway 41 (Sec. 15, T40S, R21E), Charlotte Co., Florida.

791. Bermont Fm., spoil banks, Florida Cross State Barge Canal, 1 1/2 miles west of U.S. Highway 19 at Inglis, Citrus Co., Florida.

792. Caloosahatchee Fm., borrow pits just west of Florida Highway 80, about 2 miles southwest of La Belle (SW 1/4 Sec. 7, T43S, R29E), Hendry Co., Florida.

796. Pinecrest Beds, material exposed during construction of "Alligator Alley," 12.8 miles east of Florida Highway 29 (T49S, R32E), Collier Co., Florida.

797. Pinecrest Beds, material exposed during construction of "Alligator Alley", 13.3 miles east of Florida Highway 29 (T49S, R32E), Collier Co., Florida.

801. Caloosahatchee Fm., spoil banks south side of Caloosahatchee River, 2 3/4 miles west of Ortona Lock (NW 1/4 Sec. 29, T42S, R30E), Glades Co., Florida.

802. Pinecrest Beds, Caloosahatchee Fm. and Bermont Fm. mixed, spoil banks south side of Caloosahatchee River, 4 1/4 miles west of Ortona Lock (SE 1/4 Sec. 25, T42S, R29E), Glades Co., Florida.

803. Bermont Fm., spoil banks south side of Caloosahatchee River, 2 miles west of Ortona Lock (NE 1/4 Sec. 29, T42S, R 30E), Glades Co., Florida.

810. Chipola Fm., east bank of Chipola River, opposite mouth of Taylor Branch (SW 1/4 Sec. 17, T1N, R9W), Calhoun Co., Florida.

816. Caloosahatchee Fm. and Bermont Fm. mixed, borrow pits, Cecil M. Webb Wildlife Management Area, 1.8 miles east of U.S. Highway 41 and 7.2 miles north of the Lee county line, Charlotte Co., Florida.

817. Chipola Fm., south side of Tenmile Creek, large gully on the property of Mr. A. Sexton (1967) (SE 1/4 Sec. 12, T1N, R10W), Calhoun Co., Florida.

818. Chipola Fm., Farley Creek, 0.1 mile west of bridge of Florida Highway 275 (SW 1/4 Sec. 21, T1N, R9W), Calhoun Co., Florida.

819. Chipola Fm., Farley Creek, 0.2 mile west of bridge of Florida Highway 275 (SW 1/4 Sec. 21, T1N, R9W), Calhoun Co., Florida.

820. Chipola Fm., Farley Creek, at bridge of Florida Highway 275 (SW 1/4 Sec. 21, T1N, R9W), Calhoun Co., Florida.

821. Chipola Fm., Farley Creek, 0.1 mile east of bridge of Florida Highway 275 (SW 1/4 Sec. 21, T1N, R9W), Calhoun Co., Florida.

822. Chipola Fm., Farley Creek, 1/4 mile east of bridge on Florida Highway 275 (SW 1/4 Sec. 21, T1N, R9W), Calhoun Co., Florida.

823. Chipola Fm., Farley Creek, about 2000 feet east of bridge of Florida Highway 275 (SE 1/4 Sec. 21, T1N, R9W), Calhoun Co., Florida.

824. Chipola Fm., Farley Creek, about 1/2 mile east of bridge of Florida Highway 275 (SE 1/4 Sec. 21, T1N, R9W), Calhoun Co., Florida.

825. Chipola Fm., Farley Creek at abandoned mill about 1/4 mile west of bridge of Florida Highway 275 (SW 1/4 Sec. 21, T1N, R9W), Calhoun Co., Florida.

826. Chipola Fm., Farley Creek, about 0.1 mile west of abandoned mill, which is 1/4 mile west of bridge of Florida Highway 275 (on section line between Sec. 20 & 21, T1N, R9W), Calhoun Co., Florida.

827. Chipola Fm., Farley Creek, about 1/2 mile west of bridge of Florida Highway 275 (SE 1/4 Sec. 20, T1N, R9W), Calhoun Co., Florida.

828. Chipola Fm., Farley Creek, just upstream from mouth of unnamed tributary about 3/4 mile downstream from bridge of Florida Highway 275 (SE 1/4 Sec. 20, T1N, R9W), Calhoun Co., Florida.

830. Chipola Fm., Tenmile Creek, at power line crossing about one mile west of Chipola River (SE 1/4 Sec. 12, T1N, R10W), Calhoun Co., Florida.

831. Chipola Fm., Tenmile Creek [lowest Chipola beds exposed], slightly less than one mile west of Chipola River (SW 1/4 Sec. 7, T1N, R9W), Calhoun Co., Florida.

870. Waccamaw Fm., pits on east side of North Carolina Highway 130, 2.8 miles north of Old Dock School, Old Dock, Columbus Co., North Carolina.

917. Moodys Branch Fm., Town Creek, just east of Gulf, Mobile, and Ohio Railroad bridge; about one block east of State St. and two blocks north of U.S. Highway 80, Jackson, Hinds Co., Mississippi.

932. Pinecrest Beds, east side of Kissimmee Canal and 1/2 mile south of Seaboard Air Line Railroad, south of Fort Basinger (SE 1/4 Sec. 20, T36S, R33E), Okeechobee Co., Florida.
933. Pinecrest Beds, material exposed during construction of "Alligator Alley," 21.5 miles east of Florida Highway 29, Collier Co., Florida.
939. Caloosahatchee Fm. and Bermont Fm. mixed, south side of Caloosahatchee River, 5.2 miles west of Ortona Lock (NW 1/4 Sec 36, T42S, R29E), Glades Co., Florida.
950. Chipola Fm., Chipola River, west bank about 2000 feet above Farley Creek (SW 1/4 Sec. 20, T1N, R9W), Calhoun Co., Florida.
951. Chipola Fm., Tenmile Creek, about 1 1/4 miles west of Chipola River (SE 1/4 Sec. 12, T1N, R10W), Calhoun Co., Florida.
953. Moín Fm., type locality, Moín Hill, railroad cut and adjacent ditches on road to Sandoval 4.5 km west of Puerto Limón, Costa Rica.
954. Moín Fm., hill cut immediately behind Standard Fruit Co. box factory, just west of cemetery at Pueblo Nuevo, about 2 km west of Puerto Limón, Costa Rica.
956. Moín Fm., hill slope behind Baptist Church on Highway C.R. 32 between Puerto Limón and Pueblo Nuevo, Costa Rica.
958. Gatun Fm., hillslope on east side of road from Boyd-Roosevelt Highway to "Refinería Panamá, S. A.," about 1/2 km north of junction, just east of Cativá, Prov. of Colón, Panama.
959. Gatun Formation, roadcut on road to "Refinería Panamá S. A.," about 100 m south of refinery gate, Prov. of Colón, Panama.
960. Gatun Fm., top of hill, just east of "Refinería Panamá S.A." at Isla Payardi (= Woodring loc. no. 139E), Prov. of Colón, Panama.
961. Gatun Fm., roadcuts both sides of Boyd-Roosevelt Highway, just east of Cativá (= Woodring loc. no. 138), Prov. of Colón, Panama.
964. Gatun Fm., road from Cativá to Samba Bonita Island, about 1.2 km north of Cativá, Prov. of Colón, Panama.
965. Gatun Fm., river bank just below spillway at Gatun Lock, Panama Canal, to the southwest of the lock (= Woodring loc. no. 160, 160a), Canal Zone.
967. Río Banano Fm., Río Banano, south bank, just above railroad bridge at La Bomba, Limón Province, Costa Rica.
973. Bermont Fm., spoil banks on canal L-38W, 0.8 mile south of Terrytown (which is at Broward-Palm Beach county line), on U.S. Highway 27, Broward Co., Florida.
974. Caloosahatchee Fm. and Bermont Fm. mixed, north side Caloosahatchee River, 2 1/2 to 3 1/2 miles west of center of former Lake Hicpochee (now drained) (unmapped area, T42S, R32E), Glades Co., Florida.
975. Caloosahatchee Fm., spoil banks north side Caloosahatchee River, 0 to 1/2 mile west of center of former Lake Hicpochee (now drained) (unmapped area, T42S, R32E), Glades Co., Florida.
977. Unnamed post-Pleistocene formation, Mudlump no. 90, mouth of South Pass, Mississippi River delta, Plaquemines Parish, Louisiana.
978. Bermont Fm., spoil banks at pit on south side of waterworks, about 1 1/2 miles northeast of South Bay, Palm Beach Co., Florida.
980. Pinecrest Beds, Port Charlotte Development, spoil banks on north side U.S. Highway 41, on canal 3.3 miles northwest of Florida Highway 771 (Sec. 3, T40S, R21E), Charlotte Co., Florida.
982. Pinecrest Beds, Port Charlotte Development, spoil banks on northwest side of Florida Highway 771, on canal 3 1/2 miles southwest of junction with U.S. Highway 41 (Sec. 15, T40S, R21E), Charlotte Co., Florida.
985. Pinecrest Beds, Port Charlotte Development, spoil banks about 1/2 mile northeast of Florida Highway 771, on U-shaped canal 3.3 miles southwest of junction of U.S. Highway 41 (Sec. 10, T40S, R21E), Charlotte Co., Florida.
990. Anastasia Fm., Powell rock pit, west of Florida Highway 7, between Lake Worth and Lantana, Palm Beach Co., Florida.
991. Caloosahatchee Fm., Cochran rock pit, 2 1/2 miles west of La Belle, on north side of Florida Highway 80, Hendry Co., Florida.
998. Chipola Fm., Tenmile Creek, about 1 1/4 miles west of Chipola River (SE 1/4 Sec. 12, T1N, R10W), Calhoun Co., Florida.
999. Chipola Fm., Farley Creek, about 300 yards downstream from bridge of Florida Highway 275 (SW 1/4 Sec. 21, T1N, R9W), Calhoun Co., Florida.
1000. Pinecrest Beds, APAC pits at east end of 17th street about 8 miles east of U.S. Highway 301 [now northwest of Fruitville Rd. exit, I-75] at Sarasota, (T36S, R19E), Sarasota Co., Florida.
1020. Chipola Fm., small tributary (not shown on USGS topographic map) on east bank of Chipola River about 1/2 mile below power line crossing (NE 1/4 Sec. 20, T1N, R9W), Calhoun Co., Florida.
1021. Chipola Fm., Tenmile Creek, about 2200 feet east of bridge on Florida Highway 73 (NW 1/4 Sec. 12, T1N, R9W), Calhoun Co., Florida.
1023. Caloosahatchee Fm. and Bermont Fm. mixed, pits on U.S. Highway 441, at inter-

section of Florida Highway 717, about one mile east of Pahokee, Palm Beach Co., Florida.

1028. Concepcion Inferior Fm., roadcut on east side Nueva Teapa-Ixhuatlan road 1.6 km south of junction with Mexico Highway 180, Veracruz, Mexico.

1044. Pinecrest Beds, spoil banks, west side of L-28 Interceptor Canal, 3 1/2 miles north of junction with Hendry County Highway 833, north side of Big Cypress Indian Reservation (T47S, R33E), Hendry Co., Florida.

1046. Agueguexquite Fm., roadcuts on both sides of Mexico Highway 180, 12 km east of junction with side road into Coatzacoalcos, Veracruz, Mexico. (This locality is that described in Perrilliat Montoya, 1960, p. 5).

1048. Chipola Fm., Farley Creek, about 0.8 mile east of bridge of Florida Highway 275 (NE 1/4 Sec. 21, T1N, R9W), Calhoun Co., Florida.

1050. Chipola Fm., west bank of Chipola River immediately below power line crossing, and directly across river from loc. TU 554 (SW 1/4 Sec. 17, T1N, R9W), Calhoun Co., Florida.

1051. Chipola Fm., Tenmile Creek, just downstream from large gully on property of Mr. A. Sexton (1967) (SE 1/4 Sec. 12, T1N, R10W), Calhoun Co., Florida.

1097. Chipola Fm., Tenmile Creek, recently [1972] cut-off meander, 500 yards east of Florida Highway 73 (NW 1/4 Sec. 12, T1N, R10W), Calhoun Co., Florida.

1098. Chipola Fm., Tenmile Creek, just below power line crossing (and just below TU 830) (SE 1/4 Sec. 12, T1N, R10W), Calhoun Co., Florida.

1099. Danville Landing Beds, Danville Landing, west bank Ouachita River, 1 1/2 miles upstream from Duty Ferry (NE 1/4 Sec. 22, T11N, R5E) (mile 82.2 on river markers), Catahoula Parish, Louisiana.

1173. Danville Landing Beds, head of large gully running into Ouachita River, due east of Copenhagen, which is about 5 miles airline south-east of Columbia (NE 1/4 Sec. 14, T12N, R4E), Caldwell Parish, Louisiana.

1174. Caloosahatchee Fm., spoil banks along canals north of Florida Highway 858, 1.3 miles east of junction with Florida Highway 846 (SE 1/4 Sec. 13, T48S, R27E), east of Naples and south of Immokalee, Collier Co., Florida.

1175. Pinecrest Beds and Caloosahatchee Fm. mixed, spoil banks along canals south of Florida Highway 858, 2 miles east of junction with Florida Highway 846 (SE 1/4 Sec. 24, T48S, R27E), east of Naples and south of Immokalee, Collier Co., Florida.

1177. Pinecrest Beds and Caloosahatchee Fm. mixed, Mule Pen Quarry, north side of Florida Highway 846, 9.1 miles east of U.S. 41 at Naples Park (SE 1/4 Sec. 24, T48S, R26E), Collier Co., Florida.

1196. Chipola Fm., Farley Creek, about 0.8 mile east of bridge on Florida Highway 275, approximately 500 feet upstream from TU 1048 (NE 1/4 Sec. 21, T1N, R9W), Calhoun Co., Florida.

1203. Byram Fm., quarry of Mississippi Valley Portland Cement Co., on east side of Mississippi Highway 3, 2.8 miles north of junction with U.S. Highway 61 at Redwood, Warren Co., Mississippi.

1211. Gurabo Fm., Rio Gurabo, west bank, second bluff below the ford on Los Quemados-Sabaneta road, Dominican Republic.

1215. Gurabo Fm., Rio Gurabo, bluffs on both sides, from the ford on Los Quemados-Sabaneta road, upstream to approximately 1 km above the ford, Dominican Republic.

1219. Gurabo Fm., Rio Amina, bluffs on east side of river immediately upstream from ford that is 2 km west of Potrero and about 3 km downstream from "La Represa," Dominican Republic.

1227. Gurabo Fm., Arroyo Zalaya, which crosses road to Jánico from Santiago de los Caballeros, 11 km south of bridge over Rio Yaque del Norte at Santiago, Dominican Republic.

1230. Cercado Fm., Rio Cana, east bank, just above the bridge at Caimito on Los Quemados-Sabaneta road, Dominican Republic.

1239. Moín Fm., hill cut above Standard Fruit Co. box factory at Pueblo Nuevo (same as TU 954 but stratigraphically about 10 m higher – above coral horizon), Puerto Limón, Costa Rica.

1240. Moín Fm., Barrio Los Corales, top of hill at end of road that passes Standard Fruit Co. box factory (see TU 954), 1.8 km north of main highway at Pueblo Nuevo, which is 2 km west of Puerto Limón, Costa Rica.

1241. Rio Banano Fm., Quebrada Chocolate, 6.6 km west of junction of Costa Rica Highway 32 (to San Jose) and Aeropuerto Rd. at southwest edge of Puerto Limón, Costa Rica.

1250. Gurabo Fm., Rio Verde, south bank, just above the ford at the crossing of a side road that connects Duarte Highway and La Vega-Moca Highway, about 10 km north of La Vega, Dominican Republic.

1258. Weches Fm., west side of spillway and dam of Lake Nacagdoches, on north side of Texas Highway FM 225, 10 miles west of Bypass 224, west of Nacogdoches, Nacogdoches Co., Texas.

1269. Cantaure Fm., series of arroyos about 500 m south of "Casa Cantaure" [which is literally one house and which is about 400 m south of older, now abandoned, house that was the "Casa Cantaure" of Jung, 1965, and others], 14 km (by road) west of Pueblo Nuevo, Paraguaná Peninsula, Venezuela.
1288. Red Bluff Fm., type locality, east bank Chickasawhay River, about 1 1/2 miles south of Shubuta (NE 1/4 Sec. 16, T10N, R7W), Wayne Co., Mississippi.
1289. Red Bluff Fm., east bank Chickasawhay River, about 3/4 mile south of Hiwannee (SW 1/4 Sec. 28, T10N, R7W), Wayne Co., Mississippi.
1290. Red Bluff Fm., "Carson Sand Creek", at crossing of county road 1 1/2 miles east of Hiwannee (SW 1/4 Sec. 26, T10N, R7W) [possibly Aldrich's Carson Creek loc.], Wayne Co., Mississippi.
1293. Gurabo Fm., Rio Mao, west bank, bluff just below Paso Chorrera, or about 12 km (by road) south of Mao, Dominican Republic.
1307. Moín Fm., hilltop approximately halfway between Puerto Limón and Barrio Los Corales, 0.5 km north of Highway (C.R. 32) at Pueblo Nuevo, Costa Rica.
1321. Concepcion Inferior Fm., "Kilometer 70" (of Toula, 1911), which is K 70 on Trans-Isthmus railroad south of Coatzacoalcos, K 70 is 5 km north of Almagres, Veracruz, Mexico.
1347. Agueguexquite Fm., pipeline cut, which parallels Mexico Highway 180, 12 km miles east of junction with side road into Coatzacoalcos, Veracruz, Mexico (due north of TU 1046).
1349. Pinecrest Beds, Proctor road-metal pit, off I-75, south of Sarasota, (Sec. 7, T37S, R18E), Sarasota Co., Florida.
1352. Mao Fm., Rio Gurabo, east bank at first bluff above ford that is approximately 1 km south of Gurabo Afuero, Dominican Republic.
1354. Gurabo Fm., Cañada de Zamba, a tributary on the west side of the Rio Cana, approximately 2.5 km east of the village of Zamba, which is 7 km north of Cruz de Santiago (Santiago Rodriguez), on road to Guayubin; or 4.5 km (airline) below the ford at Caimito, Dominican Republic.
1364. Baitoa Fm., Boca de los Rios, below the waterfall in Arroyo Hondo, which enters Rio Yaque del Norte from the east, just below the confluence with Rio Bao, downstream from Baitoa, Dominican Republic.
1366. Mao Fm., Rio Gurabo, west bank, aproximately 4.5 km (airline) below the ford on Los Quemados-Sabaneta road, Dominican Republic.
1397. Esmeraldas Beds, Quebrada Camarones, cut-bank on east side of canyon, which is at east edge of village of Camarones, 20 km (by road) east of bridge over Rio Esmeraldas, at Esmeraldas, or approximatley 10 km east of mouth of Rio Esmeraldas, Prov. of Esmeraldas, Ecuador.
1398. Esmeraldas Beds, roadcut at mouth of Quebrada Camarones, east side of bridge at village of Camarones, which is 20 km (by road) east of bridge over Rio Esmeraldas, at Esmeraldas, Prov. of Esmeraldas, Ecuador.
1399. Esmeraldas Beds, roadcut on west side of village of Camarones, which is 20 km (by road) east of bridge over Rio Esmeraldas, at Esmeraldas, Prov. of Esmeraldas, Ecuador.
1422. Cercado Fm., Arroyo Bellaco (or Beyaco on topographic maps), which is a tributary of Rio Cana from the east, coral reef that is exposed for approximately 1 km below the ford at Las Caobas Adentro, 3 km southwest of Las Caobas, Dominican Republic.
1431. Gatun Fm., hilltop construction site, 0.5 km northwest of intersection of Boyd-Roosevelt Highway and road to Puerto Pilon, at Sabanita, Prov. of Colón, Panama.
1432. Gatun Fm., north side Boyd-Roosevelt Highway, clearing behind Residential Martin Luther King (formerly Palo Quemado) approximately 1.5 km east of junction of road to Refinería Panamá, S.A., at Cativá, Prov. of Colón, Panama.
1433. Gatun Fm., north side Boyd-Roosevelt Highway, clearing behind Urbanization San Martin, approximately 0.5 km east of junction of road to Refinería Panamá, S.A., at Cativá, Prov. of Colón, Panama.
1458. Mint Springs Fm., stream-bed on Andrew W. Rees farm, north of Cleary, Rankin Co., Mississippi.
1460. Byram Fm., stream-bed north side of West Tallahatta Creek, east of first bridge on road south from Sylvarena, Smith Co., Mississippi.
1491. Pinecrest Beds, North Ft. Meyers, pits open during construction of Cape Coral, northwest of intersection of U.S. Highway 41 and Florida Highway 78, Lee Co., Florida.
1492. Caloosahatchee Fm., approximately 4 miles southeast of Clewiston (1 mile east and 3 miles south on road to U. S. Sugar Co. mill), Palm Beach Co., Florida.
1493. Pinecrest Beds, Arvita Pit, on Bird Road (= W. 40th St.), approximately 5 miles west of Florida Turnpike, on west side of Coral Gables, Dade Co., Florida.
1495. Moín Fm., north side San Jose-Puerto

Limón Highway (C.R. 32), 1 km east of old road to Moín, or 4.7 km west of junction with highway to Cahuita (C.R. 36), at Puerto Limón, Costa Rica.

1496. Moín Fm., north side of San Jose-Puerto Limón Highway (C.R. 32), 2 km east of old road to Moín, or 3.7 km west of junction with highway to Cahuita (C.R. 36), at Puerto Limón, Costa Rica.

1507. Angostura Fm., large point just east of Rio Verde, or approximately 30 km east of Rio Esmeraldas, Prov. of Esmeraldas, Ecuador.

1511. Cook Mountain Fm., roadcut on north side Louisiana Highway 155, 2.5 miles west of Quitman (Sec. 27, T16N, R4W), Bienville Parish, Louisiana.

1512. Caloosahatchee Fm. and Bermont Fm. mixed, DeSoto Mining Company, pits 2 miles east of Florida Highway 31, about 12 miles south of Arcadia (T39S, R25E), DeSoto Co., Florida.

1514. Concepcion Inferior Fm., roadcut 0.8 km south of junction of old Mexico Highway 180 (now side road to old bridge at Coatzacoalcos; junction is 7.3 km east of old bridge), and new bypass, Veracruz, Mexico.

1515. Concepcion Inferior Fm., roadcut just south of intersection of old Mexico Highway 180 (now side road into Coatzacoalcos; junction is 7.3 km east of old bridge), and new bypass, Veracruz, Mexico.

1524. Pinecrest Beds, Quality Aggregate Pit, off Richardson Road, north side of Fruitville Road and east of highway I-75, east of Sarasota, Sarasota Co., Florida.

1527. Weches Fm., roadcut on west side of U.S. Highway 259, 3.2 miles north of overpass over U.S. Highway 59, north of Nacogdoches, Nacogdoches Co., Texas.

The following are Tulane University Recent locality numbers:

R-42. Anna Maria Key, off Sarasota, Florida; dredged in approximately 46 m, by James Moore, Bradenton, Florida.

R-60. Steel pilings, "Texas Tower - Stage I", 12 miles off Panama City, Bay Co., Florida; 17 fms (31 m).

R-101. Off Holandes Cay, east of Cape San Blas, Panama; dredged in 42-51 m (23-28 fm), *Anton Bruun* Cruise 10.

R-109. Bahia de las Minas, Isla Payardi, Prov. of Colon, Panama (7000 YBP).

R-503. Roatan Island, south side of Oak Ridge, Islas de la Bahia (Bay Islands), Honduras.

VII. LITERATURE CITED

ABBOTT, R. T., 1974, American Seashells. Second Edition. Van Nostrand Reinhold Co., New York, 663 p., 24 color plates, 6405 text-figs.

ABBOTT, R. T., and C. J. FINLAY, 1979, *Chicoreus cosmani*, a new muricid gastropod from the West Indies: Nautilus, vol. 93 [title-page and running heads say "vol. 94"], no. 4, p. 159-162, text-figs. 1-11.

ADANSON, MICHEL, 1757, Histoire naturelle de Sénégal. Coquillages. [Part 1] Voyage au Sénégal, p. 1-190; [Part 2] Historie des Coquillages, p. i-xcvi + 1-275, 19 pls., 1 map. C. J. Bauche, Paris.

AKERS, W. H., 1972, Planktonic foraminifera and biostratigraphy of some Neogene formations, northern Florida and Atlantic Coastal Plain: Tulane Stud. Geol. Paleont., v. 9, p. 1-139, pls. 1-60, 4 text-figs., 1 map.

AKERS, W. H., 1974, Age of Pinecrest Beds, south Florida: Tulane Stud. Geol. Paleont., v. 11, no. 2, p. 119-120, 1 figure.

AKERS, W. H., 1979, Planktic foraminifera and calcareous nannoplankton biostratigraphy of the Neogene of Mexico. Pt. I–Middle Pliocene: Tulane Stud. Geol. Paleont., v. 15, no. 1, p. 1-32, pls. 1-8.

AKERS, W. H., 1980, Ancient environments and geological ages in Mexico: Proc. International Sym. on Marine Biogeography and Evolution in the Southern Hemisphere (Auckland, 17-20 July, 1987), p. 491-499, 1 text-fig.

AKERS, W. H., 1981, Planktic foraminifera and calcareous nannoplankton biostratigraphy of the Neogene of Mexico. Addendum to Part I – Some additional mid-Pliocene localities and further discussion on the Agueguexquite and Concepcion Superior beds: Tulane Stud. Geol. Paleont., v. 16, no. 4, p. 145-148, 1 text-fig.

AKERS, W. H., and P. E. KOEPPEL, 1973, Age of some Neogene formations, Atlantic Coastal Plain, United States and Mexico *in* G.C.A.G.S. Symposium Calcareous Nannofossils, Proc., L. A. SMITH and JAN HARDENBOL, Editors, p. 82-93, pls. 1-4.

ANDERSON, F. M., 1929, Marine Miocene and related deposits of north Colombia: California Acad. Sci., Proc., (ser. 4) v. 18, no. 4, p. 72-213, pls. 8-23.

ANDREWS, T. G., Jr., 1975, The streptoneuran gastropods of the Weches Formation, from Nacogdoches County, Texas. Unpublished Master's Thesis, Stephen F. Austin State University, Nacogdoches, Texas.

BAYER, F. M., 1971, New and unusual mollusks collected by R/V *John Elliott Pillsbury* and *R/V Gerda* in the tropical western Atlan-

tic: Bull. Mar. Sci., v. 21, p. 111-236, figs. 1-72.

BERNARDI, A. C., 1859, Description d'espèces nouvelles: Jour. de Conchyl., v. 7, p. 301-303, pl. 10.

BLACKWELDER, B. W., 1981, Late Cenozoic Stages and molluscan zones of the U.S. Middle Atlantic Coastal Plain: Paleontological Soc. Mem. 12 (Jour. Paleontology, v. 55, no. 5, suppl.) 35 p., 10 pls., 9 text-figs.

BLACKWELDER, B. W. and L. W. WARD, 1976, Stratigraphy of the Chesapeake Group of Maryland and Virginia: Guidebook for Fieldtrip 7b, Geol. Soc. Amer. Northeast-Southeast Sections joint meeting, Arlington, Virginia, 1976, p. 1-55, 3 pls., 15 text figs.

BOLLI, H. M., 1972, Correlación de las estaciones JOIDES 29, 30, 31 del Caribe con Jamaica, Venezuela, y Trinidad: Rep. Venezuela, Min. Minas e Hidrocarb., Bol. Geol., Publ. Espec. 5, Mem. Cuarto Cong. Geol. Venezolano, v. 3, p. 1315-1336, 3 correlation charts.

BRANN, D. C., and L. S. KENT, 1960 Catalogue of the type and figured specimens in the Paleontological Research Institution: Bulls. Amer. Paleontology, v. 40, no. 184, p. 1-996, 1 pl.

BULLIS, H. R., Jr., 1964, Muricidae (Gastropoda) from the northeast coast of South America, with descriptions of four new species: Tulane Stud. Zoology, v. 11, no. 4, p. 99-107, 1 pl., 2 tables.

CARTER, J. E., 1983, Bibliography and index of Gulf and Atlantic Coastal Plain Biostratigraphy: Univ. North Carolina, Biostrat. Newsletter, suppl. 1, 118 p.

CARTER, J. E., 1984, Explanation of the Biostratigraphy Newsletter correlation chart; Abstract of comments and correlations from subscribers and reviewers regarding correlation chart of issue 1; Additions to the Newsletter bibliography: Univ. North Carolina, Biostrat. Newsletter, no. 2, p. 4-38, correlation chart.

CIPRIANI, ROBERTO, 1990, On the distribution and morphometry of some species of *Chicoreus (Phyllonotus)* in Venezuela: Western Soc. Malac., Ann. Rept., v. 22, p. 20 [abstract].

CLENCH, W. J., and ISABEL PÉREZ FARFANTE, 1945, The genus *Murex* in the western Atlantic: Johnsonia, v. 1, no. 17, 58 p., 29 pls.

CONRAD, T. A., 1865, Descriptions of new Eocene shells, and references with figures to published species: Amer. Jour. Conchology, v. 1, pt. 3, p. 210-212, pls. 20, 21.

COOKE, C. W., JULIA GARDNER, and W. P. WOODRING, 1943, Correlation of the Cenozoic formations of the Atlantic and Gulf Coastal Plain and the Caribbean region: Geol. Soc. Amer., Bull., v. 54, p. 1713-1722, 1 pl.

DOCKERY, D. T., III, 1977, Mollusca of the Moodys Branch Formation, Mississippi: Mississippi Geol. Surv., Bull. 120, 212 p., 27 pls., 10 text-figs.

DOCKERY, D. T., III, 1980, The invertebrate macropaleontology of the Clarke County, Mississippi, area: Mississippi Bur. Geol., Bull. 122, 387 p., 82 pls., 36 text-figs.

DUBAR, J.R., 1974, Summary of the Neogene Stratigraphy of southern Florida in Post-miocene Stratigraphy central and southern Atlantic Coastal Plain, R. J. OAKS, Jr., and J. R. DUBAR, editors, Utah State University Press, p. 206-231, figs. 1-5, tables 1-7.

FAIR, R. H., 1976, The Murex book, an illustrated catalogue of Recent Muricidae (Muricinae, Muricopsinae, Ocenebrinae). Privately printed, Honolulu, Hawaii, 138 p., 23 pls., 67 text-figs.

FISCHER-PIETTE, EDOUARD, 1942, Les Mollusques d'Adanson: Jour. de Conchyl., v. 85, p. 103-366, pls. 1-16.

FISCHER-PIETTE, EDOUARD, and J. BEIGBEDER, 1943, Catalogue des types de Gastéropodes marins conservés au Laboratoire de Malacologie. I. – Genre *Murex:* Mus. Hist. Nat. Paris, Bull., (Ser. 2) v. 15, p. 203-209.

GARDNER, JULIA, 1947, The molluscan fauna of the Alum Bluff Group of Florida: U.S. Geol. Surv., Prof. Paper 142-H, p. 493-656, pls. 52-62.

GIBSON, T. G., 1983, Stratigraphy of Miocene through Lower Pleistocene strata of the United States Central Atlantic Coastal Plain: Smithsonian Cont. Paleobiology, no. 53, p. 35-80, 37 text-figs.

GIVENS, C. R., and M. P. KENNEDY, 1976, Middle Eocene mollusks from northern San Diego County, California: Jour. Paleontology, v. 50, p. 954-975, pls. 1-4, 2 text-figs., 2 tables.

GONZALEZ, A. R., and CELESTINO FLORES, 1972, Nota sobre los géneros *Thais* Roeding, *Purpura* Brugiére [*sic*] y *Murex* Linnaeus (Neogastropoda: Muricidae) en las aguas costeras de Venezuela; Inst. Oceanogr., Univ. Oriente, Bol., v. 11, no. 2, p. 67-82, 11 text-figs.

HARRIS, G. D., and K. V. W. PALMER, 1946-1947, The Mollusca of the Jackson Eocene of the Mississippi embayment (Sabine River to the Alabama River): Bulls. Amer. Paleontology, v. 30, no. 117 (in 2 parts), p. 1-563, pls. 1-65.

HAZEL, J. E., 1983, Age of correlation of the Yorktown (Pliocene) and Croatan (Pliocene and Pleistocene) formations at the Lee Creek Mine: Smithsonian Cont. Paleobiology, no. 53, p. 81-199, pls. 1-38, 4 text-figs.

HODSON, FLOYD, and H. K. HODSON, 1931,

Some Venezuelan mollusks: Bulls. Amer. Paleontology, v. 16, no. 59, p. 1-94, pls. 1-24.

HOLMES, F. S., 1860, Post-Pleiocene fossils of South Carolina. Charleston, South Carolina, 122 p., 28 pls.

HOUART, ROLAND, 1987, Rehabilitation de *Chicoreus (Phyllonotus) oculatus* (Reeve, 1845) (Gastropoda:Muricidae): Apex, v. 2, no. 1, p. 7-10, 1 pl.

HUNTER, V. F., and P. BARTOK, 1974, The age and correlation of the Tertiary sediments of the Paraguaná Peninsula, Venezuela: Asoc. Venezolana Geol., Min., Pet., Bol. Inform., v. 17, p. 143-154, 1 map.

International Commission on Zoological Nomenclature, 1961, International Code of Zoological Nomenclature adopted by the XV International Congress on Zoology. International Trust for Zoological Nomenclature. London, 176 p.

International Commission on Zoological Nomenclature, 1964, International Code of Zoological Nomenclature, Second Edition [incorporating amendments adopted by the XVI International Congress of Zoology but with no change of title page]. International Trust for Zoological Nomenclature. London, 176 p.

International Commission on Zoological Nomenclature, 1969, Opinion 886. *Purpura* Bruguière and *Muricanthus* Swainson (Gastropoda): designations of type-species under the plenery powers with grant of precedence to Thaididae over Purpuridae: Bull. Zool. Nomen., v. 26, pt. 3, p. 128-132.

International Commission on Zoological Nomenclature, 1970, Opinion 911. Six misidentified type-species in the Superfamily Muricacea (Gastropoda): Bull. Zool. Nomen., v. 27, pt. 1, p. 20-26.

JOHNSON, R. I., 1989, Molluscan taxa of Addison Emery Verrill and Katherine Jeannette Bush, including those introduced by Sanderson Smith and Alpheus Hyatt Verrill: Harvard Mus. Comp. Zool., Occ. Pap. Moll., v. 5, no. 67, p. 1-143, pls. 1-19.

de JONG, K. M., and H. E. COOMANS, 1988, Marine gastropods from Curaçao, Aruba, and Bonaire: Stud. Fauna Curaçao and Carib. Islands, v. 69, no. 214 (Natuur. Stud. Suriname en Nederlandse Antillen, no. 121), 261 p., 47 pls., maps.

JUNG, PETER, 1965, Miocene Mollusca from the Paraguaná Peninsula, Venezuela: Bulls. Amer. Paleontology, v. 49, no. 223, p. 385-652, pls. 50-79, 2 tables, 2 text-figs.

JUNG, PETER, 1969, Miocene and Pliocene mollusks from Trinidad: Bulls. Amer. Paleontology, v. 55, no. 247, p. 289-657, pls. 13-60, text-figs. 1-4.

JUNG, PETER, 1971, Fossil mollusks from Carriacou, West Indies: Bulls. Amer. Paleontology, v. 61, no. 269, p. 143-262, pls. 1-22, 2 text-figs., 1 table.

KAICHER, S. D., 1979, Card catalogue of world-wide shells, Pack no. 20, Muricidae, Part IV, nos. 1976-2069. Publ. by the author, St. Petersburg, Florida.

KAICHER, S. D., 1980, Card catalogue of world-wide shells, Pack no. 25, Muricidae, Part V, nos. 2498-2603. Publ. by the author, St. Petersburg, Florida.

KIENER, L. C., 1842-1843, Spécies général et iconographie des coquilles vivantes . . . Famille des canalifères, troisième partie, Genre Rocher. Paris, 130 p., 47 pls. [plates issued in 1842; text issued in 1843].

KOHL, BARRY, 1985, Early Pliocene benthic foraminifers from the Salina Basin, southeastern Mexico: Bulls. Amer. Paleontology, v. 88, no. 322, p. 1-173, pls. 1-36, 18 text-figs., 1 table.

LAMB, J. L., and J. H. BEARD, 1972, Late Neogene planktonic foraminifers in the Caribbean, Gulf of Mexico, and Italian Stratotypes: Univ. Kansas, Paleont. Contributions, Art. 57 (Protozoa 8), 67 p., 36 pls., 25 text-figs., 2 tables.

LEXICO ESTRATIGRAFICO DE VENEZUELA (Segunda Edición), 1970, Rep. Venezuela, Min. Minas e Hidrocarb., Bol. Geol., Publ. Espec. 4, 756 p., 2 maps, 1 correlation chart.

MACNEIL, F. S., 1937, Species and genera of Tertiary Noetinae: U.S. Geol. Surv., Prof. Paper 189-A, p. 1-50, pls. 1-6, 2 text-figs.

MACNEIL, F. A., and D. T. DOCKERY III, 1984, Lower Oligocene Gastropoda, Scaphopoda, and Cephalopoda of the Vicksburg Group in Mississippi: Mississippi Bur. Geol., Bull. 124, 415 p., 72 pls., 16 text-figs.

MAURY, C. J., 1917, Santo Domingo type sections and fossils, Pt. 1, Mollusca: Bulls. Amer. Paleontology, v. 5, no. 29, p. 165-415, pls. 27-65, map; Pt. 2, Stratigraphy: *Ibid.*, v. 5, no. 30, p. 416-460, pls. 66-68, correlation chart.

MAURY, C. J., 1925, Fosseis Terciarios do Brasil, con descripção de novas formas Cretaceas: Serv. Geol. Min. Brasil, Mon. 4 ["1924"], 665 p., 24 pls., 1 correlation table.

MOORE, E. J., 1962, Conrad's Cenozoic fossil marine mollusk type specimens at the Academy of Natural Sciences of Philadelphia: Acad. Nat. Sci. Phila., Proc., v. 114, p. 23-120, pls. 1-2.

MORGAN, J. P., J. M. COLEMAN, and S. M. GAGLIANO, 1963, Mudlumps at the mouth of South Pass, Mississippi River...: Louisiana State University Studies, Coastal Studies no. 10, 190 p.

OKUTANI, TAKASHI, 1982, A new genus and five new species of gastropods trawled from off Surinam: Venus, Jap. Jour. Malac., v. 47,

no. 2, p. 109-120, pls. 1, 2.

OLSSON, A. A., 1922, The Miocene of northern Costa Rica; with notes on its general stratigraphic relations: Bulls. Amer. Paleontology, v. 9, no. 39, p. 174-460, pls. 4-35.

OLSSON, A. A., 1964, Neogene mollusks from northwestern Ecuador. Paleontological Research Institution, Ithaca, New York, 256 p., 38 pls.

OLSSON, A. A., and ANNE HARBISON, 1953, Pliocene Mollusca of southern Florida, with special reference to those from North Saint Petersburg: Acad. Nat. Sci. Phila., Mon. 8, 457 p., 65 pls.

OLSSON. A. A., and R. E. PETIT, 1964, Some Neogene Mollusca from Florida and the Carolinas: Bulls. Amer. Paleontology, v. 47, no. 217, p. 509-574, pls. 77-83.

PALMER, K. V. W., 1937, The Claibornian Scaphopoda, Gastropoda, and dibranchiate Cephalopoda of the southern United States: Bulls. Amer. Paleontology, v. 7, no. 32, p. 1-730, pls. 1-90.

PARKER, J. D., 1948, A new *Cassis* and other mollusks from the Chipola Formation: Nautilus, v. 61, no. 3, p. 90-95, pl. 6.

PERRILLIAT MONTOYA, M. del C., 1960, Moluscos del Miocenico de la Cuenca Salina del Istmo de Tehuantepec, Mexico: Paleontología Mexicana, no. 8, 38 p., 4 pls., 2 text-figs., 1 table.

PERRILLIAT [MONTOYA], M. del C., 1972, Monografia de los Moluscos del Mioceno medio de Santa Rosa, Veracruz, México; Parte 1 (Gasterópodos: Fissurellidae a Olividae): Paleontología Mexicana, no. 32, 119 p., 51 pls., 1 table, 1 map.

PETIT, R. E., and DRUID WILSON, 1986, Publication dates of Heilprin's *Explorations on the West Coast of Florida:* Tulane Stud. Geol. Paleont., v. 19, no. 2, p. 95-96.

PETUCH, E. J., 1976, An unusual molluscan assemblage from Venezuela: Veliger, v. 18, no. 3, p. 322-325, 8 text-figs.

PETUCH, E. J., 1986, The Pliocene reefs of Miami: their geomorphological significance in the evolution of the Atlantic Coastal Ridge, southeastern Florida, U. S. A.: Jour. Coastal Research, v. 2, no. 4, p. 391-408, pls. 1-4, 5 text-figs.

PETUCH, E. J., 1987, New Caribbean molluscan faunas. Coastal Educ. & Resh. Found. (CERF), Charlottesville, Virginia, 154 + 4 p., 29 pls., 1 text-fig.

PETUCH, E. J., 1988a, A new giant *Muricanthus* from the Pliocene of southern Florida, U.S.A.: Bull. Paleomalocology, v. 1, no. 1, p. 17-21, pl. 3.

PETUCH, E. J., 1988b, Neogene History of tropical American mollusks. Coastal Educ. & Resh. Found. (CERF), Charlottesville, Virginia, 217 p., 39 pls., 23 (+ 7 unnumbered) text-figs.

PFLUG, H. D., 1961, Mollusken aus dem Tertiär von St. Domingo: Acta Humboldtiana, Ser. Geol. Paleont., no. 1, 107 p., 26 pls., 1 text-fig.

PONDER, W. F., and E. H. VOKES, 1988, A revision of the Indo-West Pacific fossil and Recent species of *Murex* s.s. and *Haustellum* (Muricidae: Gastropoda: Mollusca): Rec. Australian Mus., Suppl. 8, 160 p., 57 tables, 89 text-figs.

RADWIN, G. E., and ANTHONY D'ATTILIO, 1976, Murex shells of the world; an illustrated guide to the Muricidae. Stanford University Press, Stanford, California, 284 p., 32 colored pls., 192 text-figs.

REEVE, L. A., 1845-1846, Conchologia iconica; or illustrations of the shells of molluscous animals, v. 3, *Murex,* 36 pls. [pls. 1-34 issued Apr. to Oct., 1845; pls. 35, 36 issued Apr., 1846].

RICHARDS, H. G., 1943, Additions to the fauna of the Trent Marl of North Carolina: Jour. Paleontology, v. 17, p. 518-526, pls. 84-86.

RIOS, E. de C., 1975, Brazilian marine mollusks iconography. Museu Oceanográfico, Rio Grande, RGS, Brazil, 331 p., 91 pls.

RIOS, E. de C., 1985, Seashells of Brazil. Fundação Universidade do Rio Grande, Museu Oceanográfico, Rio Grande, RGS, Brazil, 329 p., 102 pls.

ROBINSON, EDWARD, and PETER JUNG, 1972, Stratigraphy and age of marine rocks, Carriacou, West Indies: Amer. Assoc. Petrol. Geol., Bull., v. 56, p. 114-127, 6 text-figs., 1 table.

RUTSCH, ROLF, 1934, Die gastropoden aus dem Neogen der Punta Gavilan in Nord-Venezuela; Part 1: Schweiz. Palaeont. Gesell., Abh., v. 54, no. 3, p. 1-88, pls. 1-7. Part 2: *Ibid.*, v. 55, no. 1, p. 89-169, pls. 8, 9.

SARASÚA, HORTENSIA, and JOSÉ ESPINOSA, 1978, Adiciones al género *Murex* (Mollusca:Neogastropoda): Inst. Zool., Acad. Cien. Cuba, Poeyana, no. 179, p. 1-13, 3 text-figs., 3 tables.

SARASÚA, HORTENSIA, and JOSÉ ESPINOSA, 1984, Contribución al conocimiento del orden Neogastropoda (Mollusca: Prosobranchia) en Cuba: Inst. Zool., Acad. Cien. Cuba, Poeyana, no. 273, p. 1-18, 6 text-figs.

SAUNDERS, J. B., PETER JUNG, and BERNARD BIJU-DUVAL, 1986, Neogene paleontology in the northern Dominican Republic. 1. Field surveys, lithology, environment, and age: Bulls. Amer. Paleontology, v. 89, no. 323, p. 1-79, pls. 1-9, 39 text-figs., 4 tables, 4 appendices.

SCHMELZ, G. W., 1989, Notes on the fauna of the Chipola Formation – XXXII. A new species of the genus *Cymatium* (Mollusca: Gastropoda): Tulane Stud. Geol. Paleont., v. 22, no. 4, p. 137-139, 2 text-figs.

SMITH, MAXWELL, 1940, New Recent and

fossil mollusks from Florida: Nautilus, v. 54, no. 2, p. 44-46, pl. 2.

SOWERBY, G. B. [II], 1834-1841a, The conchological illustrations, *Murex,* pls. 58-67 (issued in 1834), pls. 187-199 (issued in 1841); *Murex,* a catalogue of Recent species, 9 p., included.

SOWERBY, G. B. [II], 1841b, Descriptions of some new species of *Murex,* principally from the collection of H. Cuming, Esq.: Zool. Soc. London, Proc., pt. 8 (1840), p. 137-147.

STENZEL, H. B., E. K. KRAUSE and J. T. TWINING, 1957, Pelecypoda from the type locality of the Stone City Beds (middle Eocene) of Texas: Univ. Texas Publ. 5704, 237 p., 22 pls., 31 text figs., 4 tables.

SUTTY, LESLEY, 1986, Seashell treasures of the Caribbean. E. P. Dutton, New York, 128 p., 139 colored figures.

TOULA, FRANZ, 1911, Nachträge zur jungtertiären (Pliocanen) fauna von Tehuantepec: K.-K. Geol. Reichs., Jahr., v. 61, p. 473-486, pl. 29, 2 text-figs.

VERRILL, A. H., 1950a, New subspecies from the West Indies: Conch. Club So. California, Mins., no. 101, p. 5-7, text-fig.

VERRILL, A. H., 1950b, New Marine mollusks from Dominica, B. W. I.: Nautilus, v. 63, no. 4, p. 126-128, pls. 9, 10.

VERRILL, A. H., 1950c, A new *Murex* from the West Indies: Conch. Club So. California, Mins., no. 103, p. 4, text-fig.

VOKES, E. H., 1963a, Cenozoic Muricidae of the western Atlantic region. Part I – *Murex* sensu stricto: Tulane Stud. Geol., v. 1, no. 3, p. 93-123, pls. 1-4.

VOKES, E. H., 1963b, Notes on Cenozoic Muricidae from the western Atlantic region, with descriptions of new taxa: Tulane Stud. Geol., v. 1, no. 4, p. 151-163, pls. 1, 2.

VOKES, E. H., 1965a, Cenozoic Muricidae of the western Atlantic region. Part II – *Chicoreus* sensu stricto and *Chicoreus (Siratus):* Tulane Stud. Geol., v. 3, no. 4, p. 181-204, pls. 1-3, 2 text-figs.

VOKES, E. H., 1965b, Note on the age of the Chipola Formation (Miocene) of northwestern Florida: Tulane Stud. Geol., v. 3, no. 4, p. 205-208.

VOKES, E. H., 1967a, Observations on *Murex messorius* and *Murex tryoni,* with the description of two new species of *Murex:* Tulane Stud. Geol., v. 5, no. 2, p. 81-90, pls. 1-4.

VOKES, E. H., 1967b, Cenozoic Muricidae of the western Atlantic region. Part III – *Chicoreus (Phyllonotus):* Tulane Stud. Geol., v. 5, no. 3, p. 133-166, pls. 1-6, 1 table.

VOKES, E. H., 1968a, *Chicoreus (Siratus) carioca,* new name for *Murex calcar* Kiener: Tulane Stud. Geol., v. 6, no. 1, p. 39-40, 2 text-figs.

VOKES, E. H., 1968b, Cenozoic Muricidae of the western Atlantic region. Part IV – *Hexaplex* and *Murexiella:* Tulane Stud Geol., v. 6, no. 3, p. 85-126, pls. 1-8, 1 text-fig.

VOKES, E. H., 1969, *Murex tenuivaricosus* Dautzenberg, an older name for *Chicoreus (Siratus) carioca* Vokes (*Murex calcar* Kiener *non* Sowerby): Tulane Stud. Geol. Paleont., v. 7, no. 2, p. 84.

VOKES, E. H., 1970a, Cenozoic Muricidae of the western Atlantic region. Part V – *Pterynotus* and *Poirieria:* Tulane Stud. Geol. Paleont., v. 8, no. 1, p. 1-50, pls. 1-7, 1 text-fig.

VOKES, E. H., 1970b, *Hexaplex (Hexaplex) engonatus* (Conrad), errata and corrigenda: Tulane Stud. Geol. Paleont., v. 8, no. 1, p. 51.

VOKES, E. H., 1970c, Notes on the fauna of the Chipola Formation – II. *Chicoreus (Siratus) juliagardnerae,* new name for *Murex gardnerae* Vokes *non* Dall, with observations on the species: Tulane Stud. Geol. Paleont., v. 8, no. 1, p. 51-52.

VOKES, E. H., 1974a, Notes on *Chicoreus* (Mollusca:Gastropoda) from the Cenozoic of the western Atlantic region, with the description of new species: Tulane Stud. Geol. Paleont., v. 11, no. 2, p. 81-95, pls. 1-3.

VOKES, E. H., 1974b, Three species of Australian Muricidae (Gastropoda) with ancestors in the American Tertiary: Malac. Soc. Australia, Jour., v. 3, no. 1, p. 7-14, pls. 1-3.

VOKES, E. H., 1979, The age of the Baitoa Formation, Dominican Republic, using Mollusca for correlation: Tulane Stud. Geol. Paleont., v. 15, no. 4, p. 105-116, pls. 1, 2; 3 text-figs.

VOKES, E. H., 1980, What is my name? Or, will the real *Murex antillarum* please stand up: Of Sea and Shore, v. 11, p. 90-92, text-figs. 1-5.

VOKES, E. H., 1988, Muricidae (Mollusca:Gastropoda) of the Esmeraldas beds, northwestern Ecuador: Tulane Stud. Geol. Paleont., v. 21, no. 1, p. 1-50, pls. 1-6, 1 table, 15 text-figs.

VOKES, E. H., 1989a, An overview of the Chipola Formation, northwestern Florida: Tulane Stud. Geol. Paleont., v. 22, no. 1, p. 13-24, 11 text-figs.

VOKES, E. H., 1989b, Neogene Paleontology in the northern Dominican Republic. 8. The Family Muricidae (Mollusca: Gastropoda): Bulls. Amer. Paleontology, v. 97, no. 332, p. 5-94, pls. 1-12, 21 text-figs., 3 tables.

VOKES, E. H., 1989c, Muricidae (Mollusca: Gastropoda) of the Angostura Formation, northwestern Ecuador: Tulane Stud. Geol. Paleont., v. 22, no. 4, p. 107-118, pl. 1, 7 text-figs.

VOKES, E. H., 1989d, On the occurrence of the Caribbean species *Haustellum chrysostoma* (Gastropoda:Muricidae) in the Pliocene of

western Ecuador: Tulane Stud. Geol. Paleont., v. 22, no. 4, p. 123-127, pl. 1, 3 text-figs.

VOKES, E. H., 1990a, What ever happened to dear old *Murex*?: American Conchologist, v. 18, no. 1, p. 3-7, illustrated.

VOKES, E. H., 1990b, Two new species of *Chicoreus* subgenus *Siratus* (Gastropoda: Muricidae) from northeastern Brazil: Nautilus, v. 103, no. 4, p. 124-130, 11 text-figs.

WARD, L. W., and B. W. BLACKWELDER, 1980, Stratigraphic revision of upper Miocene and lower Pliocene beds of the Chesapeake Group, Middle Atlantic Coastal Plain: U.S. Geol. Surv., Bull. 1482-D, p. 1-61, pls. 1-5, 25 text-figs.

WEISBORD, N. E., 1962, Late Cenozoic gastropods from northern Venezuela: Bulls. Amer. Paleontology, v. 42, no. 193, p. 1-672, pls. 1-48.

WELLS, H. W., 1958, Feeding habits of *Murex fulvescens:* Ecology, v. 39, p. 556-558.

WHITE, C. A., 1887, Contribuções á paleontologia do Brazil: Mus. Nacl. Rio de Janeiro, Arch., v. 7, p. 1-273, index, pls. 1-28.

WHITTAKER, J. E., 1988, Benthic Cenozoic Foraminifera from Ecuador. British Museum (Natural History), London, xii + 194 p., pls. 1-25, 11 text-figs.

WOODRING, W. P., 1928, Miocene mollusks from Bowden, Jamaica; part 2, gastropods and discussion of results: Carnegie Inst. Washington, Publ. 385, p. 1-564, pls. 1-40.

WOODRING, W. P., 1959, Geology and paleontology of Canal Zone and adjoining parts of Panama: U. S. Geol. Surv., Prof. Paper 306-B, p. 147-239, pls. 24-38.

WOODRING, W. P., J. S. BROWN, and W. S. BURBANK, 1924, Geology of the Republic of Haiti. Republic of Haiti, Dept. of Public Works, 631 p., 40 pls., 37 text-figs.

VIII. APPENDIX I: ALPHABETICAL LIST OF SPECIES INCLUDED IN THIS PART

The following list includes all species treated systematically, as well as certain synonyms not repeated from previous parts. Thus, this is a complete list of names for all western Atlantic species, fossil and Recent, valid or invalid, referred to the genera *Murex* s.s., *Haustellum, Chicoreus,* or *Hexaplex.*

All species were originally named as "*Murex*" unless otherwise noted in brackets following the name. Those species names in ALL CAPS are new taxa described herein. The generic assignment that follows the name of the author is that one to which the species is referred in this paper. Those names without a generic assignment are considered synonyms of some other species.

adelosus Vokes, 1989. ?HAUSTELLUM
aguayoi Clench and Pérez Farfante, 1945. CHICOREUS (SIRATUS)
aldrichi Gardner, 1947. CHICOREUS (PHYLLONOTUS)
amplius [Chicoreus] Vokes, 1989. CHICOREUS (SIRATUS)
anniae M. Smith, 1940. HAUSTELLUM
antillarum Hinds, 1844. ? = *articulatus*
antillarum Gabb, 1873. = *yaquensis*
approximatus Sowerby, 1879. = *brevifrons*
arenarius Clench and Pérez Farfante, 1945. = *dilectus.*
argo Clench and Pérez Farfante, 1945. = *spectrum*
articulatus Reeve, 1845. CHICOREUS (SIRATUS)
beauii Fischer and Bernardi, 1857. CHICOREUS (SIRATUS)
bellegladeensis Vokes, 1963. HAUSTELLUM
bellus Reeve, 1845. ? = *chrysostoma*
blakeanus Vokes, 1967. HAUSTELLUM
branchi Clench, 1953. = *beauii*
brasiliensis Sowerby, 1834. = *senegalensis*
brevifrons Lamarck, 1822. CHICOREUS s.s.
briskasii Verrill, 1953. = *motacilla*
bullisi [Chicoreus] Vokes, 1974. CHICOREUS s.s.
burryi Clench and Pérez Farfante, 1945. = *fulvescens*
cabritii Bernardi, 1859. HAUSTELLUM
cailleti Petit, 1856. CHICOREUS (SIRATUS)
calcar Kiener, 1842. = *tenuivaricosus*
calcitrapa Lamarck, 1822. = *brevifrons*
carioca [Chicoreus] Vokes, 1968. = *tenuivaricosus*
carolynae [Chicoreus] Vokes, 1990. CHICOREUS (SIRATUS)
chipolanus Dall, 1890. CHICOREUS (SIRATUS)
chrysostoma Sowerby, 1834. HAUSTELLUM
ciboney Clench and Pérez Farfante, 1945. CHICOREUS (SIRATUS)
citrinus M. Smith, 1940. = *rubidus*
sp. cf. *clausii* Dunker, 1879. CHICOREUS s.s.
colei Palmer, 1937. HEXAPLEX
coltrorum [Chicoreus] Vokes, 1990. CHICOREUS (SIRATUS)
compactus Gabb, 1873. CHICOREUS (NAQUETIA)
consuela Verrill, 1950. CHICOREUS (SIRATUS)

cornurectus Guppy, 1876. CHICOREUS s.s.
corrigendum [Chicoreus] Vokes, 1989. CHICOREUS s.s.
cosmani [Chicoreus] Abbott and Finlay, 1979. CHICOREUS s.s.
costatus Gmelin, 1791. = *senegalensis*
cracherodi Sowerby, 1879. = *rubidus*

dasus Gardner, 1947. = *gilli*
davisi Richards, 1943. CHICOREUS (PHYLLONOTUS)
delicatus M. Smith, 1940. = *rubidus*
denegatus Jung, 1966. CHICOREUS (SIRATUS)
dilectus A. Adams, 1855. CHICOREUS s.s.
domingensis Sowerby, 1850. CHICOREUS (SIRATUS)
donmoorei Bullis, 1964. HAUSTELLUM
dormani Vokes, 1963. CHICOREUS (PHYLLONOTUS)
dujardinoides Vokes, 1963. CHICOREUS s.s.
dunni [Chicoreus] Petuch, 1987. CHICOREUS s.s.

elegans Beck *in* Sowerby, 1841. = *perelegans*
elusivus [Chicoreus] Vokes, 1974. CHICOREUS s.s.
emilyae [Chicoreus] Petuch, 1987. = *florifer*
engonatus Conrad, 1833. HEXAPLEX
enigmaticus [Chicoreus] Vokes, 1989. CHICOREUS s.s.
etheringtoni [Hexaplex] Vokes, 1968. HEXAPLEX
eumekes [Chicoreus] Vokes, 1989. CHICOREUS (SIRATUS)

finlayi Clench, 1955. = *articulatus*
floridanus [Chicoreus] Vokes, 1965. CHICOREUS s.s.
florifer Reeve, 1846. CHICOREUS s.s.
folidodes Gardner, 1947. CHICOREUS (PHYLLONOTUS)
formosus Sowerby, 1841. CHICOREUS (SIRATUS)
fulvescens Sowerby, 1834. HEXAPLEX
funiculatus Reeve, 1845. = *messorius*

garciai Petuch, 1987. = *messorius*
gardnerae [Alectrion] Dall, 1915. = *trophoniformis*
gardnerae Vokes, 1963. = *juliagardnerae*
gilli [Fusus] Maury, 1910. HAUSTELLUM
globosus Emmons, 1858. CHICOREUS (PHYLLONOTUS)
gosportensis Aldrich *in* Palmer, 1937. = *engonatus*
gundlachi Dunker, 1883. = *articulatus*
gustaviensis Nowell-Usticke, 1969. = *messorius*

HABROS *[Chicoreus]* Vokes. CHICOREUS (SIRATUS)
hertweckorum [Muricanthus] Petuch, 1988. HEXAPLEX

imbricatus Higgins and Marrat, 1877. = *spectrum*
imperialis Swainson, 1831. = *margaritensis*
incertum Nowell-Usticke, 1969. = *brevifrons*
infrequens Vokes, 1963. CHICOREUS (PHYLLONOTUS)
INITIALIS *[Chicoreus]* Vokes. CHICOREUS (PHYLLONOTUS)
ISTHMICUS *[Hexaplex]* Vokes. HEXAPLEX

juliagardnerae [Chicoreus] Vokes, 1970. CHICOREUS (SIRATUS)
JUNGI *[Chicoreus]* Vokes. CHICOREUS s.s.

katherinae [Hexaplex] Vokes, 1968. HEXAPLEX
kugleri Clench and Pérez Farfante, 1945. = *cailleti*

leonensis [Chicoreus] Vokes, 1967. CHICOREUS (PHYLLONOTUS)
lepidotus Vokes, 1963. CHICOREUS s.s.
LOUISAE *[Chicoreus]* Vokes. CHICOREUS (PHYLLONOTUS)
lindajoyceae Petuch, 1987. = *anniae*
maculatus Verrill, 1950. MUREX s.s.
marcoensis Sowerby, 1900. = *rubidus*
margaritensis Abbott, 1958. CHICOREUS (PHYLLONOTUS)
marksi Harris, 1894. HEXAPLEX
mergus [Chicoreus] Vokes, 1974. CHICOREUS s.s.
messorius Sowerby, 1841. HAUSTELLUM
mexicanus Petit, 1852. = *pomum*
migus de Gregorio, 1890. = *stetopus*
millvillensis Richards and Harbison, 1942. CHICOREUS (PHYLLONOTUS)
MILTOS *[Chicoreus]* Vokes. CHICOREUS (SIRATUS)
MIMIWILSONI *[Haustellum]* Vokes. HAUSTELLUM
mississippiensis Conrad, 1848. CHICOREUS (PHYLLONOTUS)
motacilla Gmelin, 1791. CHICOREUS (SIRATUS)

nicholsi Gardner, 1947. CHICOREUS (SIRATUS)
nigrescens Sowerby, 1841. = *messorius*
nodatus Reeve, 1845. = *articulatus*

oculatus Reeve, 1845. CHICOREUS (PHYLLONOTUS)
olssoni Vokes, 1967. HAUSTELLUM

pennae Maury, 1925. HAUSTELLUM
percoides Loebbecke, 1879. = *beauii*
perelegans [Chicoreus] Vokes, 1965. CHICOREUS (SIRATUS)
polynematicus Brown and Pilsbry, 1911. HAUSTELLUM
pomiformis Mörch, 1852. = *pomum*
pomatus [Chicoreus] Vokes, 1989. CHICOREUS s.s.
pudoricolor Reeve, 1845. ? = *cosmani*
pulcher A. Adams, 1853. = *consuela*
purpuratus Reeve, 1846. = *brevifrons*
pyknos Gardner, 1947. CHICOREUS (PHYLLONOTUS)

quirosensis F. Hodson, 1931. CHICOREUS (SIRATUS)

rachelcarsonae [Chicoreus] Petuch, 1987. = *dilectus*
reevei [Chicoreus] Vokes, 1965. = *ciboney*
riparius Vokes, 1963. CHICOREUS (PHYLLONOTUS)
rubidus Baker, 1897. HAUSTELLUM
rufus Lamarck, 1822. = *florifer*

sallasi Rehder and Abbott, 1951. HAUSTELLUM
salleanus A. Adams, 1854. ? = *florifer*
samui Petuch, 1987. = *messorius*
senegalensis Gmelin, 1791. CHICOREUS (SIRATUS)
septemnarius Conrad, 1834. ? = *vanuxemi*
sexangulus [Fusus] Conrad, 1834. = *engonatus*
sexcostata Emmons, 1858. = *floridanus*
SEXTONI *[Chicoreus]* Vokes. CHICOREUS (SIRATUS)
shirleyae [Chicoreus] Vokes, 1966. CHICOREUS s.s.
similis Sowerby, 1841. = *cailleti*
sirat d'Orbigny, 1841. = *senegalensis*
spectrum Reeve, 1846. CHICOREUS s.s.
spinicosta Kiener, 1842. = *fulvescens*
spinicostata Reeve, 1845. = *fulvescens*
springeri Bullis, 1964. CHICOREUS (SIRATUS)
stetopus de Gregorio, 1890. CHICOREUS (SIRATUS)
strausi Verrill, 1950. HEXAPLEX
sunderlandi Petuch, 1987. ? = *tryoni*
supernus Palmer, 1937. HEXAPLEX
surinamensis Okutani, 1982. MUREX s.s.
sutilis White, 1887. = *messorius*

tenuivaricosus Dautzenberg, 1927. CHICOREUS (SIRATUS)
texanus [Hexaplex] Vokes, 1968. HEXAPLEX
thompsoni Bullis, 1964. CHICOREUS (SIRATUS)
tingarus de Gregorio, 1890. = *stetopus*
toreia Maury, 1925. ? = *yaquensis*
toupiollei Bernardi, 1860. = *brevifrons*
triangularis Jung, 1965. = *denegatus*
trilineatus Reeve, 1845. = *ciboney*
tritonopsis Heilprin, 1886. CHICOREUS (PHYLLONTOUS)
trophoniformis Heilprin, 1886. CHICOREUS (PHYLLONOTUS)
tryoni Hidalgo *in* Tryon, 1880. HAUSTELLUM

vanuxemi Conrad, 1865. HEXAPLEX
veatchi Maury, 1910. HEXAPLEX
venezuelanus F. Hodson, 1931. CHICOREUS s.s.
VERONICA *[Chicoreus]* Vokes. CHICOREUS s.s.

woodringi Clench and Pérez Farfante, 1945. = *messorius*

xestos [Chicoreus] Vokes, 1974. CHICOREUS s.s.

yaquensis Maury, 1917. CHICOREUS (SIRATUS)
yumurinus Sarasúa and Espinosa, 1978. = *ciboney*

IX. APPENDIX II: STRATIGRAPHICAL LIST OF SPECIES INCLUDED IN THIS PART

The following list is arranged in approximately ascending stratigraphical order, with all of the species recognized as occurring in each formation.

MIDDLE EOCENE
Weches Formation, Texas
Chicoreus (Phyllonotus) initialis, n. sp.
Hexaplex texanus
Hexaplex colei
Stone City Beds
Chicoreus (Phyllonotus) initialis, n. sp.
Hexaplex colei
Cook Mountain Formation, Louisiana, Texas (= Crockett Formation), and Mississippi (= Wautubbee Formation); Lisbon Formation and Gosport Sand, Alabama.
Hexaplex vanuxemi
Hexaplex engonatus
Yegua Formation, Texas
Hexaplex vanuxemi
McBean Formation, South Carolina
Hexaplex colei

LATE EOCENE
Moodys Branch Formation, Louisiana and Mississippi
Hexaplex marksi
Hexaplex supernus
Hexaplex katherinae
Danville Landing Member, Yazoo Formation, Louisiana
Hexaplex katherinae
Hexaplex supernus
Whites Bluff Formation, Arkansas
Hexaplex marksi

EARLY AND MIDDLE OLIGOCENE
Red Bluff Formation, Mississippi
Chicoreus (Siratus) stetopus
Chicoreus (Phyllonotus) mississippiensis
Mint Springs Formation, Mississippi
Chicoreus (Siratus) stetopus
Chicoreus (Phyllonotus) mississippiensis
Bryam Formation, Mississippi
Chicoreus (Phyllonotus) mississippiensis
Chicoreus (Phyllonotus) dormani

LATE OLIGOCENE - EARLY MIOCENE
Tampa Limestone, Florida
Chicoreus (Phyllonotus) trophoniformis
Chicoreus (Phyllonotus) tritonopsis
Hexaplex veatchi
Silverdale Beds, North Carolina
Chicoreus (Phyllonotus) davisi

(?) EARLY MIOCENE
Pirabas Limestone, Brazil
Haustellum messorius
Haustellum pennae
Chicoreus (Chicoreus) cornurectus
(?) *Chicoreus (Siratus) sextoni*, n. sp.
(?) *Chicoreus (Siratus) yaquensis* (as *toreia*)

LATE EARLY MIOCENE
Cantaure Formation, Venezuela
Haustellum gilli
Chicoreus (Chicoreus) corrigendum
Chicoreus (Chicoreus) cornurectus
Chicoreus (Siratus) denegatus
Chicoreus (Siratus) quirosensis
La Rosa Formation, Venezuela
Chicoreus (Siratus) quirosensis
Baitoa Formation, Dominican Republic
Haustellum messorius
(?) *Chicoreus (Chicoreus) dujardinoides*
Chicoreus (Chicoreus) corrigendum
Chicoreus (Chicoreus) cornurectus
Chicoreus (Phyllonotus) infrequens
Chipola Formation/Oak Grove Sand, Florida
Haustellum gilli
Chicoreus (Chicoreus) lepidotus
Chicoreus (Chicoreus) dujardinoides
Chicoreus (Chicoreus) elusivus
Chicoreus (Siratus) chipolanus
Chicoreus (Siratus) juliagardnerae
Chicoreus (Siratus) sextoni, n. sp.
Chicoreus (Phyllonotus) louisae, n. sp.
Chicoreus (Phyllonotus) infrequens
Chicoreus (Phyllonotus) folidodes
Hexaplex veatchi

MIDDLE MIOCENE
Thomonde Formation, Haiti
Haustellum messorius
Chicoreus (Phyllonotus) aldrichi
Las Cahobas Formation, Dominican Republic
Haustellum messorius
Kirkwood Formation, New Jersey
Chicoreus (Phyllonotus) millvillensis
Grand Bay Formation, Carriacou, W. I.
Chicoreus (Chicoreus) jungi, n. sp.
Shoal River Formation, Florida
Chicoreus (Chicoreus) brevifrons
Chicoreus (Siratus) nicholsi
Chicoreus (Phyllonotus) aldrichi
Chicoreus (Phyllonotus) pyknos
Encanto Formation, Mexico
Haustellum messorius
Chicoreus (Chicoreus) brevifrons

LATE MIOCENE
Cercado Formation, Dominican Republic
Haustellum messorius
Haustellum pennae
?*Haustellum adelosus*
Chicoreus (Chicoreus) enigmaticus
Chicoreus (Chicoreus) cornurectus
Chicoreus (Phyllonotus) pomatus
Chicoreus (Naquetia) compactus
(?) Medias Aguas Beds, Mexico
Chicoreus (Siratus) domingensis
Chicoreus (Siratus) articulatus
Angostura Formation, Ecuador and Columbia [East Pacific]
Haustellum polynematicus

PLIOCENE
Melajo Clay, Trinidad
Haustellum chrysostoma
Chicoreus (Chicoreus) cornurectus
Courbaril Beds, Trinidad
Chicoreus (Chicoreus) cornurectus
Punta Gavilan Formation, Venezuela
Haustellum donmoorei
Chicoreus (Chicoreus) brevifrons
Chicoreus (Siratus) domingensis
Urumaco Formation, Venezuela
Chicoreus (Chicoreus) venezuelanus
Gatun Formation, Panama
Haustellum messorius
Haustellum polynematicus
Chicoreus (Chicoreus) cornurectus
Chicoreus (Chicoreus) venezuelanus
Chicoreus (Siratus) formosus
Chicoreus (Phyllonotus) globosus
Hexaplex isthmicus, n. sp.
Esmeraldas Beds, Ecuador [East Pacific]
Haustellum polynematicus
Chicoreus (Phyllonotus) globosus
Hexaplex hertweckorum
Bahía Formation, Ecuador [East Pacific]
Haustellum chrysostoma
Río Banano Formation, Costa Rica
Haustellum messorius
Haustellum mimiwilsoni, n. sp.
Chicoreus (Chicoreus) venezuelanus
Gurabo Formation, Dominican Republic
Haustellum messorius
Haustellum pennae
?*Haustellum adelosus*
Chicoreus (Chicoreus) cosmani
Chicoreus (Chicoreus) cornurectus
Chicoreus (Siratus) amplius
Chicoreus (Siratus) eumekes
Chicoreus (Siratus) yaquensis
Chicoreus (Siratus) domingensis
Chicoreus (Phyllonotus) pomatus
Chicoreus (Naquetia) compactus
Mao Formation, Dominican Republic
Haustellum messorius
Chicoreus (Chicoreus) cornurectus

Chicoreus (Chicoreus) sp. cf. *clausii*
Chicoreus (Siratus) formosus
Chicoreus (Siratus) articulatus
Chicoreus (Phyllonotus) pomum
Unnamed Mao Formation equivalent, Haiti
Chicoreus (Siratus) articulatus
Chicoreus (Siratus) ciboney
Quebradillas Limestone, Puerto Rico
Haustellum messorius
(?) *Chicoreus (Chicoreus) cornurectus*
Concepcion Inferior Formation, Mexico
Chicoreus (Siratus) miltos, n. sp.
Agueguexquite Formation, Mexico
Haustellum bellegladeensis
Chicoreus (Chicoreus) dilectus
Chicoreus (Chicoreus) veronica, n. sp.
Chicoreus (Siratus) habros, n. sp.
(?) *Chicoreus (Phyllonotus) pomum*
Pinecrest Beds, Florida
Haustellum rubidus
Chicoreus (Chicoreus) xestos
Chicoreus (Chicoreus) shirleyae
Chicoreus (Chicoreus) floridanus
Chicoreus (Phyllonotus) riparius
Chicoreus (Phyllonotus) leonensis
Chicoreus (Phyllonotus) globosus
Hexaplex hertweckorum
Jackson Bluff Formation, Florida
Chicoreus (Chicoreus) floridanus
Chicoreus (Phyllonotus) riparius
Chicoreus (Phyllonotus) leonensis
Imperial Formation, California [East Pacific]
(?) *Chicoreus (Phyllonotus) globosus*

PLIO-PLEISTOCENE
Tubará Group, Colombia
Haustellum messorius
Haustellum olssoni
Chicoreus (Chicoreus) brevifrons
Hexaplex etheringtoni
Cumaná Formation, Venezuela
Haustellum messorius
Haustellum chrysostoma
Haustellum mimiwilsoni, n. sp.
Chicoreus (Phyllonotus) globosus
Chicoreus (Phyllonotus) margaritensis
Mare Formation, Venezuela
Haustellum chrysostoma
Haustellum donmoorei
Chicoreus (Chicoreus) brevifrons
Chicoreus (Phyllonotus) pomum
Bowden Formation, Jamaica
Haustellum messorius
Chicoreus (Siratus) domingensis
Chicoreus (Siratus) formosus
Chicoreus (Siratus) articulatus
Chicoreus (Phyllonotus) pomum
Caloosahatchee Formation, Florida
Haustellum rubidus
Haustellum bellegladeensis (rare)
Chicoreus (Chicoreus) floridanus
Chicoreus (Phyllonotus) globosus
Chicoreus (Phyllonotus) pomum
Waccamaw Formation, North and South Carolina
Chicoreus (Chicoreus) floridanus
Chicoreus (Phyllonotus) globosus

PLEISTOCENE
Unnamed formation, Barbados
Haustellum messorius
Chicoreus (Chicoreus) brevifrons
Moín Formation, Costa Rica
Haustellum rubidus
Haustellum olssoni
Haustellum cabritii
Chicoreus (Chicoreus) prolixus
Chicoreus (Siratus) consuela
Chicoreus (Siratus) springeri
Chicoreus (Phyllonotus) pomum
Bermont Formation, Florida
Haustellum rubidus
Haustellum anniae
Haustellum bellegladeensis
Chicoreus (Chicoreus) dilectus
Chicoreus (Phyllonotus) pomum
Late Pleistocene formations, Florida
Chicoreus (Chicoreus) dilectus
Chicoreus (Phyllonotus) pomum
Hexaplex fulvescens

RECENT [West Atlantic]
(?) *Murex (Murex) surinamensis, maculatus*

Haustellum messorius, chrysostoma, rubidus, donmoorei, olssoni, anniae, bellegladeensis, sallasi, cabritii, blakeanus, tryoni (+ sunderlandi)

Chicoreus (Chicoreus) cosmani, dilectus, florifer, dunni, mergus, bullisi, brevifrons, spectrum

Chicoreus (Siratus) consuela, coltrorum, ciboney, formosus, articulatus, springeri, thompsoni, beauii, senegalensis, tenuivaricosus, motacilla, cailleti, perelegans, aguayoi, carolynae

Chicoreus (Phyllonotus) globosus, pomum, margaritensis, oculatus

Hexaplex fulvescens, ?strausi

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GENERA OF THE BIVALVIA: A SYSTEMATIC AND BIBLIOGRAPHIC CATALOGUE – ADDENDA AND ERRATA

HAROLD E. VOKES
TULANE UNIVERSITY

INTRODUCTION

In the early 1950's the writer prepared a mimeographed bibliographic list of the genera of the Bivalvia as an aid to those engaged in the preparation of that section of the *Treatise on Invertebrate Paleontology*. This list proved to be of such interest that in 1967, at the suggestion of the late Katherine V. W. Palmer, it was published in the *Bulletins of American Paleontology* (Vol. 51, No. 232). As a supplement to the *Treatise* (Vols. N 1-3), it rapidly became out-of-print. A revised and updated version issued by the Paleontological Research Institution in 1980 has also proved to be a popular tool for students of the Bivalvia.

The writer's interest in this molluscan Class has led him to continue his generic catalogue. The following list includes those names that have been noted in the ten years since the 1980 issue of the catalogue. It has not been possible to make extended trips to libraries outside of Louisiana and the present list is based largely on publications available in the libraries at Tulane University and Louisiana State University. It must also be noted that some of the reference journals, such as *Biological Abstracts* and the Russian *Referativnyi Zhurnal* do not give the page numbers on which the generic names were described; these are cited herein as "p.? (not seen)." Names preceeded by a dagger "†" are based upon fossil type species, those in all capital letters are believed to be nomenclatorially valid, those in italics are invalid.

My sincere appreciation is expressed to Philippe Bouchet of the Muséum National d'Historie Naturelle, Paris, and to Alan R. Kabat of the Museum of Comparative Zoology, Harvard University, for their assistance. And special mention must be made of the great amount of help afforded by the labors of my wife, Emily H. Vokes, who has devoted many hours to the preparation of this list, reading and rereading the typescript to ensure accuracy and uniformity of style and format.

ADDENDA

The following are additions to the list given in the 1980 edition; the numbers following the family or subfamily names refer to the pages in that edition.

NUCULOIDA, Incertae - 1, 220

†**NUCULODONTA** Liljedahl, 1983, Sveriges Geol. Unders. Afh., (C) (799): 31
†**LUSITANULA** Fürsich & Werner, 1987, Geol. Norandina, 73 (1,2): 110
†**ORYZOCONCHA** He & Pei, 1985, Chengtu Geol. Inst., Jour., 1985 (1): (p. ?, not seen)
†**PROSILICULA** Heinberg, 1989, Bull. Geol. Soc. Denmark, 37 (3-4): 227-236 (not seen)

CTENODONTIDAE - 1, 220

†**CAESARIELLA** Liljedahl, 1984, Sveriges Geol. Unders. Afh., (C) (804): 19
†**CALLICYMBULA** Saveliev, 1969, Small Low. Cret. Biv. Moll. Manglishlaka & northern PreCaspia: Palaeont. Sborn. 4; Trudi VNIGRI, (268): 22
Cymbula Saveliev, 1969, Small Low. Cret. Biv. Moll Manglishlaka & northern PreCaspia: Palaeont. Sborn. 4; Trudi VNIGRI, (268): 11 [non H. & A. Adams, 1854 (Gastr., Patellidae)]
†**KAZACHIA** Bazhenova, 1971, Zapiski Leningr. Gorn. Inst., 59 (2): 92
†**KUFRALARIA** H. & G. Termier, 1980, in Salem & Busrewil, Geol. Libya, 1: 307
†**LONGICYMBULA** Saveliev, 1969, Small Low. Cret. Biv. Moll. Manglishlaka & northern PreCaspia: Palaeont. Sborn. 4; Trudi VNIGRI, (268): 19

PRAENUCULIDAE - 1, 220

†**BICRENULA** Zhang Ren-jie, 1984, Acta Palaeont. Sinica, 23 (5): 587 (Chinese), 595 (English)
†**POJETAIA** Jell, 1980, Alcheringa, 4: 234 [assigned to Fordillidae by Jell, subsequently transferred to Praenuculidae by Runnegar and Bentley, 1983, Jour. Paleont., 57 (1): 74-92]

THORALIIDAE, New Family Morris, 1980
[insert after Radiidentidae - 220]

†**THORALIA** Morris, 1980, Bull. Brit. Mus (Nat. Hist.), (Geol.) 34 (4): 270

NUCULIDAE - 1, 220

†**ECONOMOLOPSIS** Hoare, Heaney & Mapes, 1989, Jour. Paleont., 63 (5): 585
†**PSEUDONUCULA** Dinkins, 1989, Bur. Min. Res., J. Australian Geol. Geophysics, 11 (1): 63-80 (not seen)
†**SINONUCULA** Xu, 1984, Studia Mar. Sinica, (22): 182
†**SPATHELOPSIS** Hoare, Heaney & Mapes, 1989, Jour. Paleont., 63 (5): 586
†**VARINUCULA** Maxwell, 1988, New Zealand Paleont. Bull. 54: 35

MALLETIIDAE - 3, 221

ACUTISPINULA Filatova & Schileko, 1984, Tsitologiya, 119: 109 [nom. nov. pro *Spinula* Dall, 1908, non Herrich-Schaeffer, 1856 (Lepid.)]
†**AUSTRALONEILO** Zinsmeister, 1984, Jour. Paleont.,58 (6): 1502
Ivigriella (?err. pro. *Vnigr-* Saveliev, 1969) auct. ?, 1975, State of Knowledge, Biv. Moll.: 346
†**LAPTEVIELLA** Kurushin, 1985, in Dagys & Kurushin, Trudi Akad. Nauk SSSR, In-ta Geol. Geofiz., Sib. Otd., (633): 47
†**NEILOIDES** Freneix, 1980, Ann. de Paléont. Invert., 66 (2): 13
†**PALAEOSTRABA** Liljedahl, 1984, Sveriges Geol. Unders. Afh., (C) (804): 13

ANTACTINODIONTIDAE, New Family Guo, 1980

†**ANTACTINODION,** valid as of Guo, 1980 [see 1980 ed. of catalogue, p. 257)
†**DYSODONTA** Mansuy, 1913 [see 1980 ed., p. 3, - included in n. family by Guo]
†**LEIODYSODONTA** Pojeta, Zhang & Yang, 1986, U.S. Geol. Surv. Prof. Pap. 1394-G: 69

NUCULANIDAE - 5, 221

AMPHILATA Filatova & Schileko, 1984, Tsitologiya, 119: 129
†**AUSTRALOPORTLANDIA** Zinsmeister, 1984, Jour. Paleont., 58 (6): 1504
INTERCALARIA Filatova & Schileko, 1984, Tsitologiya, 119: 134
LEDELLINA Filatova & Schileko, 1984, Tsitologiya, 119: 127
†**PHESTIOIDEA** Pojeta, Zhang & Yang, 1986, U.S. Geol. Surv., Prof. Pap. 1394-G: 63
PRASHADIA Filatova & Schileko, 1984, Tsitologiya, 119: 127
†**PSEUDONUCULANA** Pojeta, Zhang & Yang, 1986, U.S. Geol. Surv., Prof. Pap. 1394-G: 63
SCISSULADRANA Petuch, 1987, New Caribbean Molluscan Faunas: 116
SETIGLOMA Schileko, 1983, Byull. Mosk. Obshch. Ispyt. Prir. (Otd. Biol.), 88 (4): 97
SINOLEDA Xu, 1984, Studia Mar. Sinica, (22): 168

VETERANELLINAE New Subfamily J. Chen, Lui & Lan, 1983

Proposed to included the following genera (nos. refer to pages in 1980 ed.): *Veteranella* (7), *Glyptoleda* (5), *Girtyana* (5), *Costatoleda* (5), *Hilgardia* (5), *Nucundata* (6), *Ledoides* (221), *Indonuculana* (221), and *Zealeda* (7), plus:

†**ELEGANUCULANA** J. Chen & Yang, 1983, Acta Palaeont. Sinica, 22 (3): 355 (Chinese), 358 (English)
Indoculana (err. pro *Indonucul-* Kanjilal & Singh, 1980) J. Chen, Liu & Lan, 1983, Acta Palaeont. Sinica, 22 (6): 620 (Chinese), 625 (English)
†**QIONGZHOUNIA** Lan, 1983, Acta Palaeont. Sinica, 22 (6): 622 (Chinese), 626 (English)

†**TEINONUCULANA** Zhang, 1977, Palaeont. Atlas Central-South China, (2): 9
†**XIAOSHUICULANA** J. Chen, 1983, Acta Palaeont. Sinica, 22 (6): 622 (Chinese), 626 (English)

SOLEMYIDAE - 8

†**VORKUTELLA** Muromzeva & Guskov, 1984, Permian Marine Deposits Bivalve Moll. Soviet Arctic; Nedra, Leningrad: 35

PRAECARDIIDAE - 8, 222

†**FENTOUNIA** Liu, 1983, Palaeont. Atlas East China: (1, Early Paleozoic): 294
†**PSEUDOCOSTATORIA** Sinitsyna, 1986, Vopr. Paleont., 9: 65
†**SLAVINKA** Kriz, 1982, Vestnik Ustred. Ust. Geol., 57 (4): 237

ARCOIDA, Family Uncertain - 10

†**FREJA** Liljedahl, 1984, Sveriges Geol. Unders. Afh., (C) (804): 36

ARCINAE - 11, 222

Trisides (err. pro- *dos* Röding, 1798) Abbass, 1972 [1973], Egyptian Jour. Geol. (Jour. Geol. UAR), 16 (1): 83

PARALLELODONTIDAE - 15, 223

Antonella Astafieva-Urbaitis & Ramova, 1985, Palaeontologia Jugosl., (33): 14 [non Cooke & Kondo, 1960]

GRAMMATODONTINAE - 16, 223

†**PLATYGRAMMATODON** Bousteyak, 1972, Compt. Rend., Sem. Geol., Tananarive, 1971: 14
†**STENOCOLPUS** Yamani, 1982, Mitt. Bayer. Staatsamml., Paläont., Hist. Geol., (22): 25

CUCULLAEIDAE - 16, 223

†**AUSTROCUCULLAEA** Zinsmeister, 1988, in Feldmann & Woodborne (eds), G.S.A. Mem. 169: 259
†**PARALOPATINIA** Sanin, 1984, in Sanin, Zakharov & Shurygin, Trudi Akad. Nauk SSSR, In-ta Geol. Geofiz., Sib. Otd., (585): 71

NOETIIDAE - 17, 223

†**OKINAWANOARCA** Noda, 1980, Sci. Repts. Inst. Geosciences, Univ. Tsukuba, (B, Geol. Sci.) 1: 74
SCELIDIONARCA Oliver, 1987, Jour. Conch., 32 (5): 286

STRIARCINAE - 18, 223

†**QUADRILATERA** Deshayes, 1860, Desc. Anim. sans Vertebres, 1: 866
Quadrilatera Sandberger, 1863 [non Deshayes, 1860] - see 1980 ed., p. 18
†**RIBRIARCA** Noda, 1980, Sci. Repts. Inst. Geosciences, Univ. Tsukuba, (B, Geol. Sci.) 1: 75
†**SCALENOETIA** Oliver, 1987, Jour. Conch., 32 (5): 270

GLYCYMERIDAE - 20, 223

†**BELLAXINEA** Nichol & Jones, 1984, Nautilus, 98 (3): 126

MYTILIDAE - 22, 224

Bathymodiolus Le Pennac, Lucas & Petit, 1984, Haliotis, 13: 70 [nom. nud.]
BATHYMODIOLUS Kenk & Wilson, 1985, Malacologia, 26 (1-2): 255 (made type species of n. sub-

family Bathymodiolinae)
BENTHOMODIOLUS Dell, 1987, Rec. Natl. Mus. New Zealand, 3 (3): 31
CRASSIMYTILUS Scarlato & Starabogatov, 1979, Trudi Akad. Nauk. SSSR, Zool. In-ta, 80: 108
DIVARIMYTILUS Kafunov, 1984, in Morph., Syst., Phylogeny, Ecology Bivalved Moll.: Nauka : 44
†**EOMYTILUS** Yamani, 1976, Neues Jahrb. Geol. Palaont., 1976 (1): 42
Gelkensia (err. pro. *Geuk-* Van der Poel, 1959) Zool. Rec., 1983 (9): 517, with reference to Blasco et al., 1979, Rev. Assoc. Geol. Argentina, 34 (4): page not cited
†**MODIOMYTILUS** Griffin, 1990, Jour. Paleont., 64 (3): 377
PACIFIMYTILUS Kafunov, 1984, in Morph., Syst., Phylogeny, Ecology Bivalved Moll.: Nauka: 44
†**REGULIFERA** Fürsich & Werner, 1987, Geol. Norandina, 73 (1,2): 127
†**SANDA** Geyer, 1987, Neues Jahrb. Geol. Paläont Abh., 173 (3): 281
†**STRIMODIOLUS** Fürsich, 1982, Groenl. Geol. Unders. Bull., 144: 22
†**STRIOMODIOLUS** Badve & Nayak, 1984, Bio-Vigyanam, 10 (1): 69
TUMIDIMYTILUS Kafunov, 1984, in Morph., Syst., Phylogeny, Ecology Bivalved Moll.: Nauka: 44

PINNIDAE - 28, 224

†**CONULARIOPSIS** Sugiyama, 1942, Jour. Geol. Soc. Japan, 49: 395 [described as Triassic conulariid; placed in synonymy of *Pinna* s.s. by Murata, 1978, Kumamoto Jour. Sci. (Geol.) 11 (1): 11]

AMBONYCHIIDAE - 30, 224

†**CARINONYCHIA** Pojeta, Zhang & Yang, 1986, U.S. Geol. Surv., Prof. Pap. 1394-G: 90
†**KOGULANYCHIA** Isakar, 1985, Eesti NSV Tead. Akad. Teim (Geol.), 34 (1): 30
†**NODONYCHIA** Pojeta, Zhang & Yang, 1986, U.S. Geol. Surv., Prof. Pap. 1394-G: 90

ALATOCONCHIDAE, New Family Termier, Termier & Lapparent, 1973
[insert after Ambonychidae - 31, 225]

Includes the following genera: *Alatochoncha* (224), *Shikamaia* (225), *Tanchingtongia* (225), plus:

†**DERECONCHA** Yancey & Boyd, 1983, Palaeontology, 26 (3): 518
†**SAIKRACONCHA** Yancey & Boyd, 1983, Palaeontology, 26 (3): 512

MYALINIDAE - 31, 225

†**CIGARELA** Astafieva, 1988, Paleont. Zhurn., 1988 (4): 23
†**CYRTOKOLYMIA** Astafieva 1988, Paleont. Zhurn., 1988 (2): 29
†**DORCADUNGULA** Bensaid, Termier, Termier & Vacahard, 1978 [1979], Ann. Sci. Géol., (NS) 98 (3): 194
†**FYLGIA** Liljedahl, 1989, Geol. Foren. Stockl. Forh., 111 (4): 339

PTERINEIDAE - 34, 226

†**INGARA** Sinitsyna, 1986, Vopr. Paleont., 9: 67
†**MOLINICOLA** , Liljedahl, 1984, Sveriges Geol. Unders. Afh., (C) (804): 53
†**OXYTOMOIDEA** Pojeta, Zhang & Yang, 1986, U.S. Geol. Surv., Prof. Pap. 1394-G: 97
†**PTERINOACTINODESMA** Livshina, 1967, Uchenye Zap. Nauchno-islad., In-ta Geol. Arkt., Paleont. Biostrat., (20): 58
†**URALOPTERIA** Kulikova, 1983, Ezhegodnik Vses. Palaeont. Obshch., 26: 151
†**WUXUANITES** Pojeta, Zhang & Yang, U.S. Geol. Surv., Prof. Pap. 1394-G: 98

PTERIIDAE - 36, 226

†**GUICHIELLA** Li & Ding, 1981, Acta Palaeont. Sinica, 20 (4): 320 (Chinese), 329 (English)

BAKEVELLIIDAE - 38, 226

†**BOREIOBAKEVELLIA** Kurushin, 1980, Trudi Akad. Nauk SSSR, In-ta Geol. Geofiz., Sib. Otd., (448): 72
†**GERVILLETIA** Damborenea, 1987, Palaeontographia, Abt. A: 199 (4-6): 139
†**NANLINGELLA** Xiong & Wang, 1980, Mesozoic fossils of coal-bearing strata in Hunan, Habei & Jiangxi Provinces, (2) Bivalvia: Meitan Gonye Chuban She: 23
†**SPIA** Skwarko, 1981, Bur. Min. Res., Geol. Geophys., Australia, Bull. 209: 64
†**TUARKYRIA** Prozorovskii, 1977, Ezhegodnik Vses. Paleont. Obshch., 19: 29

INOCERAMIDAE - 40, 226

†**ORDINATOCERAMUS** Zonova, 1982, in Abley, Krasnov, etc., New Data Stratig. Palaeogeography Soviet Far East: Akad. Nauk, Vladivostok: 116
†**RHYSSOMYTILOIDES** Hessel, 1988, Fossils Strata no. 22: 25
†**SORNAYCERAMUS** Tsagareli & Ghambashidze, 1984, Paleont. Sb., Lemberg, (21): 52 (also spelled as *Sorneiceramus*).
†**VARVARIA** Astafieva, 1985, in Astafieva-Urbaitis & Astafieva, Paleont. Zhurn., 1985 (4): 115

MALLEIDAE - 45, 227

NEOAVICULOVULSA Okutani & Kusakari, 1987, Venus, Jap. Jour. Malac., 46 (1): 1
†**XENIUM** Gorbach, 1985, Paleont. Sb., Lemberg, (22): 32

PTERINOPECTINIDAE - 46, 227

†**PSEUDOCLARAIA** Zhang, 1980, Acta Palaeont. Sinica, 19 (6): 438 (Chinese), 443 (English)

AVICULOPECTINIDAE - 47, 227

†**ANSHUNOPECTEN** ... [listed in Yin Hongfu, 1985, Jour. Paleont., 59 (3): 588 - orig. description not found]
†**FLETCHERIPECTEN** Waterhouse, 1982, New Zealand Paleont. Bull. 49: 24
†**GLABRIPECTEN** Waterhouse, 1982, New Zealand Paleont. Bull. 49: 27
†**IMOELLA** Hoare, Heaney & Mapes, 1989, Jour. Paleont., 63 (5): 592
†**JUNGGAROCHONDRIA** Yang, 1983, Atlas Fossils Xinjiang Prov., (2, Up. Paleoz.): 414 [also cited as new genus by Yang & Chen, 1985, Acta Palaeont. Sinica, 24 (4): 382 (Chinese), 386 (English)]
†**NEOMORPHOTIS** Yin & Yu, 1983, in Yang, et al., Triassic South Quilian Mtns.: 155
†**NEOPECTEN** Bychov, 1985, Mesozoic Bivalvia & Cephalopoda from N. E. USSR: Akad. Nauk: 11
†**PARADOXIPECTEN** Zhang, 1981, Acta Palaeont. Sinica, 20 (3): 262 (Chinese), 264 (English)
†**PERICLARAIA** Li & Ding, 1981, Acta Palaeont. Sinica, 20 (4): 327 (Chinese), 330 (English)
†**PRAEOTAPIRIA** Kurushin, 1985, in Dagys & Kurushin, Trudi Akad. Nauk. SSSR, In-ta Geol. Geofiz., Sib. Otd., (633): 106
†**PTERIPECTEN** Sanchez, 1984, Biostratigraphie Palaeozoique, 2: 42
†**TIANSHANOPECTEN** Feng Quing-lai, 1988, Acta Palaeont. Sinica, 27 (5): 632 (Chinese), 636 (English)
†**VNIGRIPECTEN** Muromzeva, 1984, in Muromzeva & Guskov, Permian Marine Deposits & Bivalve Moll. Soviet Arctic; Nedra, Leningrad: 65
†**XINJIANGOPECTEN** Yang, 1981, Atlas fossils Xinjiang Prov. (2, Up. Paleoz.): 414 [also cited as new genus by Yang & Chen, 1985, Acta Palaeont. Sinica, 24 (4): 381 (Chinese) 385 (English)]

CHAENOCARDIIDAE - 48

†**STRIATOCHONDRIA** Waterhouse, 1983, Bull. Indian Geol. Assoc., 16 (2): 156

EUCHONDRIINAE - 48

†**ENDOCOSTAPECTEN** Feng Quing-lai, 1988, Acta Palaeont. Sinica, 27 (5): 624 (Chinese), 636 (English)

†**EUCHONDRIOIDES** Fang, 1987, Nanjing Dishi Gusher, Yanjiushend Lunwenji, (1): 349-411 (not seen)

DELTOPECTINIDAE - 48, 228

†**CORRUGOPECTEN** Waterhouse, 1982, New Zealand Paleont. Bull. 49: 38
†**MORRISIPECTEN** Muromzeva & Guskov, 1984, Permian Marine Deposits & Bivalve Moll. Soviet Arctic; Nedra, Leningrad: 75
†**UNDOPECTEN** Waterhouse, 1982, New Zealand Paleont. Bull. 49: 38
†**VORKUTOPECTEN** Guskov, 1984, in Muromzeva & Guskov, Permian Marine Deposits & Bivalve Moll. Soviet Arctia; Nedra, Leningrad: 73

POSIDONIIDAE - 48, 228

†**ASMUSSIA** Pacht, 1849, Der Devonische Kalk in Livland [Estonia]: 44
†**GUERICHIA** Rzehak, 1910, Der Brünner Clymenienkalk; Zisch. Mähr Landesmus., 10 (2): 209 (as *Gürichia)*
†**PERIBOSITRA** Chen, 1981, Bull. Nanjing Inst. Geol. Paleont.; Acad. Sinica, 1981 (2): 54 (Chinese), 81 (English)
†**PERIHALOBIA** Gruber, 1976, Mitteil. Ges. Geol., Berghaust, 23: 192
†**PRAEAMONOTIS** Waterhouse, 1987, Palaeontographica, Abt. A, 198 (4-6): 157

OXYTOMIDAE - 49, 228

†**CANADARCTOTIS** Jeletzky & Poulton, 1987, Canadian Jour. Earth Sci., 24 (4): 718
†**CANADOTIS** Jeletzky & Poulton, 1987, Canadian Jour. Earth Sci., 24 (4): 712

ENTOLIIDAE - 49, 228

†**CALVAENTOLIUM** Romanov, 1985, Jurassic Pectinoids Southern SSSR: Shtiintsa, Kishiner: 35
†**CINGENTOLIUM** Yamani, 1983, Mitt. Bayer. Staatssamml. Paläont., Hist. Geol., (23): 6
Cingentolum (err. pro *-olium* Yamani, 1983) auct. ?, 1984, Biol. Abstracts; 78 (7): 5882
†**COLPENTOLIUM** Yamani, 1983, Mitt. Bayer. Staatssamml. Paläont., Hist. Geol., (23): 12
†**CORNUTOENTOLIUM** Romanov, 1985, Jurassic Pectinids Southern SSSR: Shtiintsa, Kishiner: 52
†**COSTENOLIUM** Freneix, 1980, Ann. de Paléont. Invert., 66 (2): 23
†**NEOENTOLIUM** Romanov, 1985, Jurassic Pectinoids Southern SSSR: Shtiintsa, Kishiner: 37
†**PALAEOENTOLIUM** Romanov, 1985, Jurassic Pectinoids Southern SSSR: Shtiintsa, Kishiner: 35
†**SEYMOURTULA** Zinsmeister, 1988, in Feldmann & Woodbourne (eds.), G. S. A. Mem. 169: 269
†**VARIENTOLIUM** Andreeva, 1976, Trudi Upravlenija Geol. Soveta Ministror Tadghikskoj SSR, Paleont. Strat. (Nedra Moskva). 2: 20

PECTINIDAE - AMUSIUM Group - 50, 228

†**AMUSSIOPSIS** Andreeva, 1976, Trudi Upravlenija Geol. Soveta Ministror Tadzhikskoj SSR, Paleont. Strat. (Nedra Moskva) 2: 22

PECTINIDAE - CAMPTONECTES Group - 51, 229

†**COSTICAMPTONECTES** Fürsich, 1982, Groenl. Geol. Unders., Bull. (144): 50

PECTINIDAE - CHLAMYS Group - 52, 229

†**BATEQUEUS** Squires & Demetrion, 1990, Jour. Paleont., 64 (3): 383
†**CAROLINAPECTEN** Ward & Blackwelder, 1987, Smithsonian Contr. Paleobiology, (61): 141
†**EUTHYMIPECTEN** Dhondt & Dieni, 1988, Early Cretaceous Bivalves Eastern Sardinia; Mem. Scienze Geologiche, Univ. Padova, 40: 30
†**FIBROSOPECTEN** Romanov, 1985, Jurasic Pectinoids Southern SSSR: Shtiinta, Kishiner: 123
†**KOLYMONECTES** Milova, 1976, Strat. & Biv. Moll., Triassic Jurassic, Northern Priookhotsh Region: Nauka, Moscow: 67

†**LEPIDOPECTEN** Woodring, 1982, U.S. Geol. Surv., Prof. Pap. 306-F: 592
†**MINERVAPECTEN** Romanov, 1985, Jurassic Pectinoids Southern SSSR: Shtiintsa, Kishiner: 129
†**NIPPONONECTES** Tashiro, 1982, Mem. Fac. Sci. Kochi Univ., (E) 3: (p. ?, not seen)
†**OCHOTOCHLAMYS** Milova, 1976, Strat. & Biv. Moll., Triassic Jurassic, Northern Priookhotsh Region: Nauka, Moscow: 61
†**PAMIROPECTEN** Romanov, 1985, Jurassic Pectinoids Southern SSSR: Shtiintsa, Kishiner: 133
†**PERAPECTEN** Wagner, 1985, Basteria, 49 (4-6): 84
†**SUBULATOCHLAMYS** Romanov, 1985, Jurassic Pectinoids Southern SSSR: Shtiintsa, Kishiner: 154
†**TITONOPECTEN** Romanov, 1985, Jurassic Pectinoids Southern SSSR: Shtiintsa, Kishiner: 156

PECTINIDAE - HINNITES Group - 54, 229

CRASSADOMA Bernard, 1986, Venus, Jap. Jour. Malac., 45 (1): 70
PSEUDOHINNITES Dijkstro, 1989, Basteria, 53: 29-33 (not seen)

PECTINIDAE - DECATOPECTEN Group - 54, 230

SOMALIPECTEN Waller, 1986, Nautilus, 100 (2): 41

PECTINIDAE - NEITHEA Group - 56

†**INDIGIROPECTEN** Truschelev, 1984, Trudi Akad. Nauk SSSR, In-ta Geol. Geofiz., Sib. Otd., (600): 66
†**LYWEA** Damborenea, 1987, Palaeontographica, Abt. A, 199 (4-6): 185

PECTINIDAE - Group Uncertain - 57, 230

†**ALTAIPECTEN** Yang & Chen, 1985, Acta Palaeont. Sinica, 24 (4): 383 (Chinese), 386 (English)
†**AMUROPECTEN** Sey, 1984, in Poyarkova (ed.), New Data Biostrat. Phanerozoic Soviet Far East; Akad. Nauk, SSSR Vladivostok: 94
BATHYPECTEN Schein-Fatton, 1985, Compt. Rend. Acad. Sci., Paris, (III) 301 (10): 491
†**CAPEDOPECTEN** Dijkstra & Janssen, 1988, Basteria 52 (4-6): 176
†**CRENAMUSSIUM** Newton, et al., 1987, Paleont. Soc. Mem. (22): 46
†**JANUPECTEN** Arkhipov & Trushchelev, 1980, Trudi Akad. Nauk SSSR, In-ta Geol. Geofiz., Sib. Otd., (448): 10
KARNEKAMPIA Wagner, 1988, Basteria, 52 (1-3): 4

MONOTIDAE - 57, 230

†**ETALIA** Begg & Campbell, 1985, New Zealand. Jour. Geol. Geophys., 28 (4): 727
†**PACIMONOTIS** Grant-Mackie & Silberling, 1990, Jour. Paleont. 64 (2): 247

PLICATULIDAE - 57, 230

†**TRICHIPLATULA** Chiplonkar & Tapaswi, 1975, Bio-Vigyanam, 1 (1): 95

BUCHIIDAE - 57, 230

†**ALLOBUCHIA** Yu, 1983, Bull. Shenyang Inst. Geol., Min. Resources, (7): 43 (Chinese), 46 (English)
†**AUSTRALOBUCHIA** Zakharov, 1981, Trudi Akad. Nauk SSSR, In-ta Geol. Geofiz., Sib. Otd., (458): 46
†**JELETZKIELLA** Jones & Plafker, 1977, Init. Repts. Deep-Sea Drilling Project, 36: 647
†**PRAEBUCHIA** Zakharov, 1981, Trudi In-ta Akad. Nauk SSSR, Geol. Geofiz., Sib. Otd., (458): 58

TERQUEMIIDAE - 58

†**LATINEWAAGIA** Yin & Yin, 1983, in Yang, et al., Triassic South Quilian Mtns.: 159

ANOMIIDAE - 59, 230

†**EONOMIA** Fürsich & Palmer, 1982, Palaeontology, 25 (4): 901
†**JURANOMIA** Fürsich & Werner, 1989, Geobios, 22 (3): 331
†**TARTURIA** Strougo, 1983, Bull. Soc. Paleont. Italica, 22 (1-2): 122
†**VERTINOMIA** Calzada, 1980, Bull. Roy. Soc. Esp., Hist. Nat., (Geol.) 77 (3-4): 171

LIMIDAE - 60, 321

†**CALCICANICULARIA** Waterhouse, 1983, Papers, Dept. Geol., Univ. Queensland, 10 (3): 164
†**ECHINORBIS** Waterhouse, 1987, Palaeontographica, Abt. A; 198 (4-6): 160
Ostreopecten Quenstedt, 1867, Handb. der Petrefactenkunde, (ed. 2) 2: 773 [= *Ctenostreon* Eichwald, 1862]

GRYPHAEIDAE

PYCHNODONTEINAE - 63, 231

†**CONRADOSTREA** Ward & Blackwelder, 1987, Smithsonian Contr. Paleobiology, (61): 144
Costellata Garcia & Levy, 1983, Rev. Assoc. Geol. Argentina, 38 (2): 283 [invalid, no type designation]
†**EUPYCHNODONTE** Freneix, 1979, K. Mus. Midden-Afr., Turvuren, Belg., Ann. Reeks Octavo Geol. Wet., (86): 104
NUMISMOIDA Harry, 1985, Veliger, 28 (2): 132
PARAHYOTISSA Harry, 1985, Veliger, 28 (2): 130
†**PEGMA** Squires & Demetrion, 1990, Jour. Paleont., 64 (3): 386
PLIOHYOTISSA Harry, 1985, Veliger, 28 (2): 132

OSTREINAE - 65, 231

BOONEOSTREA Harry, 1985, Veliger, 28 (2): 145
†**BOSOSTREA** Chiplonkar & Badve, 1978, Proc. Indian Acad. Sci., (B) 87 (6): 106
CRYPTOSTREA Harry, 1985, Veliger, 28 (2): 144
†**CUSSETOSTREA** Chiplonkar & Badve, 1979, Proc. Indian Acad. Scl., (B) 88 (1) (vi): 443
†**FRENEIXOSTREA** Amard, Collignon & Roman, 1983, Doc. Lab. Geol., Lyon HS, 6, 1981 [1983]: 85
†**INDICTENOSTREON** Tapasui, 1980, Bio-Vigyanam, 6: 187
†**KONBOSTREA** Chinzei, 1986, Palaeontology, 29 (1): 140
NANOSTREA Harry, 1985, Veliger, 28 (2): 142
PARASTRIOSTREA Harry, 1985, Veliger, 28 (2): 151
PLANOSTREA Harry, 1985, Veliger, 28 (2): 143
PUSTULOSTREA Harry, 1985, Veliger, 28 (2) 147
†**SOLENISCOSTREA** Chiplonkar & Badve, 1979, Proc. Indian Acad. Sci., (B) 88 (1) (vi): 444
TESKEYOSTREA Harry, 1985, Veliger, 28 (2): 145
†**TIOSTREA** Chanley & Dinamani, 1980, New Zealand Jour. Mar. & Freshwater Res., 14 (2): 116
UNDULOSTREA Harry, 1985, Veliger, 28 (2): 147
†**UNICA** Gorbach, 1985, Paleont. Sb., Lemberg, (22): 31

LOPHINAE - 67, 231

MYRAKEENA Harry, 1985, Veliger, 28 (2): 138

? LOPHINAE - 67

†**BEYLOPHA** Vialov, 1983, Dokl. Akad. Nauk, Ukr. SSR (B: Geol., Khim., Biol. Nauki) (11): 7 ? (not seen)
†**FALCOSTREA** Vialov, 1983, Dokl. Akad. Nauk Ukr. SSR, (B: Geol., Khim., Biol. Nauki) (11): 7 ? (not seen)
†**GRYPHAELIGMUS** Lewy, 1982, Jour. Paleont., 56 (3): 811 [assigned to Malleidae, transferred to Ostreidae by Waller, 1985, Jour. Paleont., 59 (3): 768]

OSTREACEA - 62

The following generic names (+ erroneous spellings, etc.) assigned to the Malleidae have, on the basis of their shell structure, been transferred to the Ostreacea by Waller [1978, Phil. Trans. Roy. Soc., London, (B) 284: 361]: (from p. 45, 1980 ed.) *Beaumontia, Bouleigmus, Chalmasia, Eligmus, Euphenax, Exputens, Heligmina, Heligmopsis;* (from p. 46) *Nayadina, Ostreinella, Proeligmus, Pseudoheligmus.*

MODIOMORPHIDAE - 69, 232

†**MODIODONTA** Liljedahl, 1989, Geol. Foren. Stockh., Forh., 111 (4): 314

KINERKAELLIDAE - New Family
[fide Zool. Rec., v. 125, 1988/89, p. 463; insert after Modiomorphidae]

†**BUNGURIA** Tokareva, 1988, Trudi Akad. Nauk SSSR, In-ta Geol. Geofiz., Sib. Otd., (707): 113
†**RAGOZINELLA** Betekhtina, 1988, Trudi Akad. Nauk SSSR, In-ta Geol. Geofiz., Sib. Otd., (707): 115
†**SAONELLA** Betekhtina, 1988, Trudi Akad. Nauk SSSR, In-ta Geol. Geofiz., Sib. Otd., (707): 116

CYCLOCONCHIDAE - 71

†**ANANTERODONTA** Babin & Gutierrez-Marco, 1985, Geobios, 18 (5): 611

ARCHANODONTIDAE - 71

†**JUNJAGIANA** Yatsuk, 1979, Trudi Akad. Nauk SSSR, In-ta Geol. Geofiz., Sib. Otd., (431): 71

ANTHRACOSIIDAE - 71, 233

†**SEYEDINA** Jatsuk, 1987, in Betekhtina, Starabogatov & Jatsuk, Trudi Akad. Nauk SSSR, In-ta Geol. Geofiz., Sib. Otd., (688): 46
†**SHAANXICONCHA** Liu & Li, 1980, Biv. Foss., I: Triassic: in Mesozoic Strat. Palaeont. Shanxi, Gangsii & Ningxia, (2): Chinese Acad. Geol. Sci., Inst. Geol. - Dizhi Chuban She: 6
†**VERNEUILUNIO** Starabogatov, 1987, in Betekhtina, Starabogatov & Jatsuk, Trudi Akad. Nauk SSSR, In-ta Geol. Geofiz., Sib. Otd., (688): 41
†**ZVONAREVIA** Tokareva, 1988, Trudi Akad. Nauk SSSR, In-ta Geol. Geofiz., Sib. Otd., (707): 111

PRILUKIELLIDAE - 72, 233

†**TALBEICA** Jatsuk, 1987, in Betekhtina, Starabogatov & Jatsuk, Trudi Akad. Nauk SSSR, In-ta Geol. Geofiz., Sib. Otd., (688): 47

PALAEOMUTELIDAE - 72, 233

†**HINGANODON** Liang, 1982, Bull. Shenyang Inst. Geol. Min. Res., 1982 (4): 138 (Chinese), 145 (English)
†**NEONUCULITES** Liang, 1982, Bull. Shenyang Inst. Geol. Min. Res, 1982 (4): 140 (Chinese), 145 (English)
†**SOLONODON** Liang, 1982, Bull. Shenyang Inst. Geol. Min. Res., 1982 (4): 136 (Chinese), 145 (English)

PSEUDOCARDINIIDAE - 72, 234

†**APSEUDOCARDINIA** Liu & Zhu, 1978, in Cai & Liu, Palaeont. Atlas Southwest China, (2) Sichuan Prov.: S.W. Geol. Inst., Peking: 392 [also cited as "Palaeont. Atlas, Southwest China, Pt. 2, non-marine Lamellibranchia"]
†**FENGJIACONCHA** Wu, 1981, Jurassic Bivalves Fengia Chong in Liling, Hunan Prov., Geol. Not. 27 (5): 375-383 [not seen - referred to Pseudocardiniidae by Ma-Qitong, Acta Palaeont. Sincia, 1989]

†**GUANDONGELLA** Li & Li, 1977, in Zhang et al., Palaeont. Atlas Central south China, (3, Bivalvia): 26 [invalid, no type desig.]; Liu & Chen, 1982, Geol. Soc. Amer., Spec. Pap. 187: 115
†**HAMICONCHA** Huang, Wei & Chen, 1981, Geol. Soc. Amer., Spec. Pap. 187: 120
†**HUNANELLA** Xiong & Wang, 1980, Acta Palaeont. Sinica, 19 (5): 362
†**JIANGXIELLA** Liu, 1976, in Gu et al., Fossil Lamellibr. China: 56
†**LILINGELLA** Chen & Yu, 1977, in Zhang et al., Palaeont. Atlas Central South China, (3, Bivalvia): 42
†**XINYUELLA** Chen & Yu, 1980, Acta Palaeont. Sinica, 19 (5): 362 (Chinese), 366 (English)
Yananoconcha (err. pro *Yunan-* Yu & Zhang, 1980) Ma Qi-hong, 1989, Acta Palaeont. Sinica, 28 (5): 604-616
†**YUNANOCONCHA** Yu & Zhang, 1980, Biv. Foss., II: Jurassic: in Mesozoic Strat. Palaeont. Shanxi, Gangsii & Ningxia, (2): Chinese Acad. Geol. Sci., Inst. Geol. - Dizhi Chuban She: 38
†**ZYRJANOCONCHA** Yakushina, 1983, Ezhegodnik vses. Paleont. Obschch. [L. Cret. Moll. Momo-Zyrgan Basin, N.E. USSR], 26: 166

MARGARITIFERIDAE - 73, 234

KURILINAIA Zatrawkin & Boyaton, 1987, Trudi Zool. In-ta, Akad. Nauk SSSR, Leningrad, 171: 158
†**MENGYINAIA** J. Chen, 1984, Acta Palaeont. Sinica, 23, (2): 149 (Chinese), 154 (English)

UNIONINAE - 73, 234

†**EONIPPONONAIA** Guo, 1981, Palaeont. Sinica, (NS) (96): 65
†**LIOPLICATOUNIO** Ma, 1983, Acta Palaeont. Sinica, 22 (6): 672 (Chinese), 675 (English)
†**PSEUDOLANCEOLARIA** Zykin, 1980, Paleont. Zhurn., 1980 (3): 40
†**RADIOPLICATA** Huang, 1981, Acta Palaeont. Sinica, 20 (2): 203
†**RHEINBRAUNIA** Schlickum & Strauch, 1979, Abhandl. Senckenb. Naturf. Ges., (536): 62
†**SHADININAIA** Starabogatov, 1983, in Zatravkin, Unionidae Fauna SSSR: in Moll. System., Ecol., Akad. Nauk, SSSR: 40
†**SINONIA** Guo, 1981, Palaeont. Sinica (NS) (96): 66
†**TROITSKINAIA** Zykin, 1980, Paleont. Zhurn., 1980 (3): 36

ANODONTIDAE - 83, 236

BERINGIANA Starabogatov, 1983, in Zatravkin, Unionidae Fauna SSSR: in Moll. System., Ecol., Akad. Nauk, SSSR: 42
KUNASHIRIA Starabogatov, 1983, in Zatravkin, Unionidae Fauna SSSR; in Moll. System., Ecol., Akad. Nauk SSSR: 42
OGURANODONTA Kuroda & Habe, 1987, Venus, Jap. Jour. Malac., 45 (4): 215 (Japanese), 217 (English)

UNIONIDAE, Subfamily Uncertain - 237

†**ACUNEOPSIS** Liu & Zhu, 1978, in Cai & Liu, Palaeont. Atlas Southwest China, (2) Sichuan Prov.; S. W. Geol. Inst., Peking: 371
†**COMPTIO** Liu & Luo, 1978, in Cai & Liu, Palaeont. Atlas Southwest China, (2) Sichuan Prov.; S. W. Geol. Inst., Peking: 358
†**DANLENGICONCHA** Liu, 1978, in Cai & Liu, Palaeont Atlas Southwest China, (2) Sichuan Prov.; S. W. Geol. Inst., Peking: 375
†**JISHUICONCHA** Ding, Liu, & Sun, 1982, Palaeont. Atlas East China, (3) Mesozoic & Cenozoic: 64
†**LUOCHENGELLA** Liu & Zhu, 1978, in Cai & Liu, Palaeont. Atlas Southwest China, (2) Sichuan Prov., S. W. Geol. Inst., Peking: 370
†**QIYANGIA** J. Chen & Yu, 1980, Acta Palaeont. Sinica, 19 (5): 358 (Chinese), 365 (English)

ALASMIDONTINAE - 87, 237

ALASMIDENS Clarke, 1981, Smithsonian Contrib. Zool., (326): 35

HYRIINAE - 91, 237

AUSTRALIS Bonetto, Tassara & Rumi, 1986 [1987], Bol. Soc. Biol. Concepcion, 57: 60

TRIGONOIDIAE [PACHYCARDIIDAE] - 95, 238

†**ZHIFANGIA** Liu, 1980, Bivalve Fossils, I: Triassic, in Mesozoic Strat. & Palaeont. Shangxi, Gansii & Ningxia (2): Chinese Acad. Geol. Sci., Inst. Geol. Dizhi Chuban She: 21

MYOPHORIIDAE - 96, 238

†**CALEDOGONIA** Freneix & Avias, 1977, Alcheringa, 1 (3-4): 282
†**ERUGONIA** Newton, et al., 1987, Paleont. Soc. Mem., 22: 63

LYRODESMATIDAE - 96,238

†**TROMELINODONTA** Babin,1982, Geobios, 15 (3): 423

TRIGONIIDAE - 97, 238

†**DAMPIETRIGONIA** Tashiro, 1979, Trans., Proc., Palaeont. Soc. Japan, (NS) (116): 205
†**HESLINGTONIA** Fleming, 1987, New Zealand Paleont. Bull. 53: 22
†**JHABOTRIGONIA** Badve & Nayak, 1984, Bio-Vigyanam, 10 (1): 72
†**KUPENGA** Fleming, 1985, Strat. Palaeont., Malacology: Papers in Honor of Dr. Nell Ludbrook; S. Austral. Dept. Mines Ener.: 58
†**MACROTRIGONIA** Camacho & Olivero, 1985, An. Acad. Nac. Cienc. Exactus Fis. Nat., Buenos Aires; 37: 51
†**MAPUTRIGONIA** Leanza, 1985, Bol. Acad. Nac. Cienc., (Cordoba), 56 (3-4): 278
†**NAKANOTRIGONIA** Tashiro, 1979, Trans., Proc., Palaeont. Soc. Japan, (NS) (116): 210
†**NANOTRIGONIA** Tapaswi, 1980, Bio-Vigyanam, 6: 187
†**PARANDITRIGONIA** Perez & Reyes, 1983, Rev. Geol. Chile, (19-20): 61
†**PAULCKELLA** Cooper, Perez & Reyes, 1989, Rev. Geol. Chile 16 (1): 53
†**QUADRATOJAWORSKIELLA** Reyes & Perez, 1977, Inst. Invest. Geol. Chile, Bull., 30: 15 [invalid, no descr. or type desig.]; 1980, Pacific Geol., 14: 88
†**SAVELIEVITRIGONIA** Repman, 1979, Paleont. Zhurn., 1979 (4): 129
†**SCAPHORELLA** Leanza, Perez & Reyes, 1987, Ameghiniana, 24 (1-2): 83
†**TRIGONELLINA** Parnes, 1981, Bull. Geol. Surv. Israel, (74): 36
†**TURBITRIGONIA** Kelly, 1984, Palaeont. Soc. Mon. 138: 91
†**TURKESTANELLA** Tashiro, 1979, Trans., Proc., Palaeont. Soc. Japan, (NS) (116): 207
†**UTETRIGONIA** Petuch, 1988, Bull. Paleomalac., 1 (3): 53
†**VIRGOTRIGONIA** Alleman, 1985, Bol. Soc. Geol. Peru (75): 1
†**ZULUTRIGONIA** Cooper, 1990, Ann. S. Afr. Mus., 99 (3): 25

TRIGONIOIDIDAE - 100, 239 (?, should be in Unionacea)

†**CYOTRIGONIOIDEA** Guo, 1981, Palaeont. Sinica, (NS) (96): 63
†**PLEDGIA** Ludbrook, 1985, Trans. Roy. Soc. S. Australia, 109 (3-4): 79

TRIGONIACEA, Family Uncertain - 100

†**WEICHANGELLA** Yu & Yao, 1980, Acta Palaeont. Sinica 19 (4): 327 (Chinese), 330 (English)

FORDILIDAE - 100, 239

†**BULUNIELLA** Ermak, 1986, Akad. Nauk SSSR., In-ta Geol. Geofiz., Sib. Otd., Trudi, (669): 186

LUCININAE - 101, 239

Codokia (err. pro *Codakia* Scopoli, 1777) Abbass, 1972 [1973], Egyptian Jour. Geol (Jour. Geol. UAR) 16 (1): 148-150
KELETITES Oliver 1986, Basteria, 50 (1-3): 53

MILTHINAE - 103, 239

†**HADROLUCINA** Woodring, 1982, U.S. Geol. Surv., Prof. Pap. 306-F: 623
†**MATANZIELLA** Frassinetti, 1978, Rev. Geol. Chile, (5): 50

CHAMIDAE - 108, 240

†**TRICHICHAMA** Tapaswi, 1979, Bio-Vigyanam, 4 (2): 93

KELLIIDAE - 109, 241

PARABORNIA Boss, 1965, Amer. Mus. Novitates, (2215): 2

MONTACUTIDAE - 112, 241

BOREACOLA Bernard, 1979, Contr. Sci. Nat. Hist. Mus. Los Angeles County, Cal., (313): 36

PERMAPHORIDAE - 116, 241

†**OUAMOUIA** Campbell, 1984, Alcheringa, 8 (2): 158
†**SOMAREOIDES** Skwarko, 1983, Austral. Bur. Min. Res., Geol. Geophys., Bull. 217: 67

CARDITIDAE - 117, 242

†**AINICARDITA** Popov, 1983, Trudi Palaeont. In-ta, Akad. Nauk (Moscow), 203: 58
CRASSICARDIA Savitsky, 1979, B. Kh. Palaeont. Strat. Dalnego Vostoka, Vladivostok: 67

ASTARTIDAE - 121, 242

†**BUNGOELLA** Tashira, Matusda & Tanaka, 1985, Mem. Fac. Sci. Kochi Univ. (Ser. E, Geol.), 5-6: 12
†**FLATTOPIA** Waterhouse, 1987, Palaeontographica, Abt. A, 198 (4-6): 163
†**GOEFFBONDIA** Cooper, 1988, South Afr. Jour. Geol., 91 (3): 322
†**PERMARTELLA** Yancey, 1985, Jour. Paleont., 59 (5): 1293

CRASSATELLIDAE - 123, 243

CRASSASULCA Vokes, 1988, Annals Natal Mus. 29 (2): 535
Eucrassinella Cruz, 1980, Acta Oceanografica del Pacifico, 1 (1): 66 [invalid, no type designated]
†**MARVACRASSATELLA** Ward & Blackwelder, 1987, Smithsonian Contr. Paleobiol., (61): 151

CARDINIIDAE - 124

†**JANAIJA** Truschelev, 1984, Akad. Nauk SSSR, In-ta Geol. Geofiz., Sib. Otd., Trudi (600): 69

CARDIIDAE, Subfamily Uncertain - 126

†**INDOCARDIUM** Chiplonkar & Badve, 1976, Bull. Ind. Geol. Assoc., 9 (1): 53

CARDIIDAE (?Fraginae) - 128, 243

PROFRAGUM Badve, 1977, Bio-Vigyanum, 3: 61

PROTOCARDIINAE - 128, 243

†**TAMILICARDIA** Chiplonkar & Tapaswi, 1976, Bio-Vigyanan, 2: (2): 152
†**TOBARUM** Noda, 1988, Sci. Repts., Inst. Geosciences, Univ. Tsukuba (B. Geol. Sci.), 9: 74

LYMNOCARDIIDAE - 130, 244

†**ACOBAECARDIUM** Paramonova, 1986, in Neveskaya et al., Trudi Palaeont. In-ta, Akad. Nauk, Moscow, 220: 192

†**ANDRUSOVICARDIUM** Paramonova, 1986, in Neveskaya et al., Turdi Palaeont. In-ta, Akad. Nauk, Moscow, 220: 192
†**KOZHURIA** Popov, 1983, Paleont. Zhurn., 1983 (3): 33
†**MERKLINOCARDIUM** Popov, 1982, Palaeont. Zhurn., 1982 (4): 43
†**MIRICARDIUM** Paramonova, 1986, in Neveskaya et al., Trudi Palaeont. In-ta, Akad. Nauk, Moscow, 220: 193
†**RARICARDIUM** Paramonova, 1986, in Neveskaya et al., Trudi Palaeont. In-ta, Akad. Nauk, Moscow, 220: 191

DIDACNINAE - 131, 244

†**LUXURIDACNA** Papaianopol, 1980, Dari Seama Geol. Inst. Romania, 65 (3): 47
†**OSOINA** Stevanovic, 1978, Geol. Anali Balk. Poluost., 42: 324
†**PROTOPLAGIODACNA** Stevanovic, 1978, Geol. Anali Balk. Poluost., 42: 339

? LYMNOCARDIIDAE - 133, 245

†**MICHAILOWIA** Bagadasarjan, 1987, Akad. Nauk, Zool. Inst., Leningrad; Abstracts of Papers: Eight meeting, Invest. of Moll: 83

MACTRIDAE - 134, 245

†**CASPIMACTRA** Ionesi, 1986, Analele Stiint. Univ. Al. I. Cuza, (N.S., Geol., Geogr.), 32: 29
†**CHERSONIMACTRA** Paramonova, 1978, Rept. 2nd Vses Symposium on Morph., System., Phylog. & Ecol., Biv. Moll.: 38
†**DOBROGIMACTRA** Ionesi, 1986, Analele Stiint. Univ. Al. I. Cuza, (N.S., Geol., Geogr.), 32: 28
†**EOPAPYRINA** Woodring, 1982, U.S. Geol. Surv., Prof. Pap. 306-F: 648
†**OVAMACTRA** Woodring, 1982, U. S. Geol. Surv., Prof. Pap. 306-F: 631
†**PLANIMACTRA** Ionesi, 1986, Analele Stiint. Univ. Al. I. Cruza, (N.S., Geol., Geogr.), 32: 29
†**PODOLIMACTRA** Ionesi, 1986, Analele Stiint. Univ. Al. I. Cruza, (N.S., Geol., Geogr.), 32: 28

TELLINIDAE - 141, 246

†**MIRATELLINA** Woodring, 1982, U. S. Geol. Surv., Prof. Pap. 306-F: 660
†**SAULELLA** Zinsmeister, 1983, Jour. Paleont., 57 (6): 1287

MESODESMATIDAE - 139, 246

†**CALIFADESMA** Saul, 1989, Veliger, 32 (2): 200

MACOMINAE - 145, 246

Gnstrana (err. pro *Gast*-Schumacher, 1817) Abbass, 1972 [1973], Egyptian Jour. Geol. (Jour. Geol. UAR), 16 (1): 172

DONACIDAE - 146, 247

†**ADELODONAX** Saul, 1989, Veliger, 32 (2): 194
†**ALIODONAX** Saul, 1989, Veliger, 32 (2): 191
†**SARMATIDONAX** Bagdasarjan, 1986, in Neveskaya et al., Turdi Palaeont. In-ta, Akad. Nauk, Moscow, 220: 189

PSAMMOBIIDAE - 147, 247

Godracus & *Gordacus* (err. pro *Gobraeus* Leach, 1852) Abbass, 1972, [1973], Egyptian Jour. Geol. (Jour. Geol. USAR), 16 (1): 166, 168 (as *Godracus*), 167 (as *Gordacus*)
†**SINOPSAMMOBIA** Li, Yu, Yao & Gu, 1982, Bull. Shenyang Inst. Geol., Min. Res., (5): 135 (Chinese), 157 (English)

SEMELIDAE - 151, 247

PRISMABRA Nordsieck, 1972, Die Miozäne Mollusken fauna von Miste-Winterswijk NL (Hemmor): 42

SOLECURTIDAE - 153

†**PROTAGELUS** Tapaswi, 1979, Bio-Vigyanam, 5 (1): 93

DREISSENIDAE - 154, 248

†**MODIOLODREISSENA** Babak, 1983, Trudi Palaeont. In-ta, Akad. Nauk, Moscow, 204: 51

BERNARDINIDAE - 158

STOHLERIA Coan, 1984, Veliger, 27 (2): 231

NEOMIODONTIDAE - 159, 249

†**GANSUELLA** Ma, 1986, Mem. Najiing Inst. Geol. Palaeont., Acad. Sinica, (22): 187 (Chinese), 202 (English)
†**MIFUNEA** Tamura, 1977, Mem. Fac. Educ. Kumamoto Univ., (Nat. Sci., 26): 128
†**NEOMIODONOIDES** Ma, 1986, Mem. Nanjing Inst. Geol. Palaeont., Acad. Sinica, (22): 169 (Chinese), 202 (English)

GLOSSIDAE - 160

Cytterocardia (err pro *Cythero-* Sacco, 1990) Mordvilko, 1979, Early Cret. Heterodont Biv. Moll., Southern SSSR (Arcticidae & Glossidae): Izdatel. Nauka Akad. Nauk, Moscow: 76
Subisocardia "Douvillé, 1921" Mordvilko, 1979, Early Cret. Heterodont Biv. Moll., Southern SSSR (Arcticidae & Glossidae): Izdatel. Nauka Akad. Nauk. Moscow: 100. [Douvillé, 1921, Bull. Soc. Géol., France, (4) 21 (1): 126 (cited by Mordviko as source of *Subisocardia*), states: "*Venilicardia* ... (*V. similis* du Cretace du England, *sub Isocardia*) ..." p. 122, "*Venilicardia* ... se prolonger dans l'Eocene (*V. carinata* Desh., du Lutetian, *sub Isocardia*)". On p. 119 he cited *Anisocardia* "*vicinalis* Tq. & J. (*sub Lucina*)" and "*An. cyreniformis* Buv. (*sub Cardium*)". It is clear that Douvillé was simply citing the original generic assignments of the species - not proposing new generic or subgeneric names. If the Mordvilko usage be interpreted as validating name *Subisocardia* it must be cited as "Douvillé in Mordvilko, 1979: type *Isocardia similis* J. Sowerby" and will be invalid as an objective synonym of *Tortarctica* Casey, 1961.]

CORBICULIDAE - 162, 249

†**CYRENORITA** Janssen, 1981, Archiv fur Molluskenkunde, 111 (4-6): 245
†**HAYAMINA** Ohta, 1982, Trans., Proc. Palaeont. Soc. Japan, (NS) (128): 444 [nom. nov. pro *Neumayria* Ohta, 1981]
†**HAIDATINA** Ohta, 1981, Bull. Fukuoka Univ. Educ. (Nat. Sci.), 31 (3): 111
Neumayria Ohta, 1981, Bull. Fukuoka Univ. Educ. (Nat. Sci.), 31 (3): 117 [non de Stefani, 1877 (Gastr.): see *Hayamina* Ohta, 1982]
†**YOSHIMOA** Ohta, 1981, Bull. Fukuoka Univ. Educ. (Nat. Sci.), 31 (3): 110

PISIDIIDAE - 164, 250

ASIOCYCLAS Starabogatov & Kornyushin, 1986, Trudi Zool. In-ta, Akad. Nauk SSSR, 152: 37
ASIOMUSCULIUM Starabogatov & Kornyushin, 1986, Trudi Zool. In-ta, Akad. Nauk SSSR, 152: 40
EUROPISIDIUM Starabogatov, 1984, in Stadnichenko, Fauna Ukraini, 29 (2): 346
HIBERNEUGLESIA Starabogatov, 1984, in Stadnichenko, Fauna Ukraini, 29 (2): 245
KUIPERIPISIDIUM Izzatullaev & Starabogatov, 1986, Trudi Zool. In-ta, Akad. Nauk SSSR, 148: 65
MORIMUSCULIUM Starabogatov & Kornyushin, 1986, Trudi Zool. In-ta, Akad. Nauk SSSR, 152: 40

PARVIMUSCULIUM Starabogatov & Kornyushin, 1986, Trudi Zool. In-ta, Akad, Nauk SSSR, 152: 39
PATAGOMUSCULIUM Starabogatov, 1986, in Starabogatov & Kornyushin, Trudi Zool. In-ta, Akad. Nauk SSSR, 152: 40
PULCHELEUGLESA Starabogatov, 1984, in Stadnichenko, Fauna Ukraini, 29 (2): 285
SHADINICYCLAS Starabogatov & Kornyushin, 1986, Trudi Zool. In-ta, Akad. Nauk SSSR, 152: 38
TUVAPISIDIUM Izzatullaev & Starabogatov, 1986, Trudi Zool. In-ta, Akad. Nauk SSSR, 148: 63
USSURIPISIDIUM Izzatullaev & Starabogatov, 1986, Trudi Zool. In-ta, Akad. Nauk SSSR, 148: 69

CIRCINAE - 168, 250

†**PARAGOULDIA** Miller, 1985, Tulane Stud. Geol. Paleont., 18 (3): 123

PITARINAE - 170, 250

†**AUSTROCALLISTA** Erdmann & Morra, 1985, Ameghiniana, 22 (3,4): 292
†**GOSHORAIA** Tamura, 1977, Mem. Fac. Educ., Kumamoto Univ. (Nat. Sci.), (26): 139

GEMMINAE - 174, 251

NUTRICOLA Bernard, 1982, Venus, Jap. Jour. Malac., 41 (2): 147

TAPETINAE - 175, 251

†**COCKBURNIA** Zinsmeister, 1984, Jour. Paleont., 58 (6): 1522
†**NEOVENERELLA** Gontscharova, 1986, Paleogene Neogene Moll., Far East and Eastern Paratethys; Akad. Nauk, Vladivostok: 94

CHIONINAE - 177, 251

Cranithaca (err. pro *Gran-* Fischer-Piette & Vukadinovic, 1977) Edwards, 1980, Zool. Rec., 114 (9, Moll., 1977): 325

PETRICOLIDAE - 179, 251

Layonkairea (err. pro *Lajon-* Deshayes, 1841) Barsotti, 1982, Quaderni Storia Nat. Livorno, 3: 46

RZEHAKIIDAE - 180

†**ERGENICA** Gontscharova, 1981, Paleont. Zhurn., 1981 (2): 31 [as "gen. nov." with ref. to Zhichenko, 1953, p. 206 "(nom. nud.)" but with no mention of the Zhickenko 1958 paper listed in the 1980 edition of this catalogue (p. 180) - a reference furnished by Merklin (in litt.) who, in a "*Rzehakia cimlanica* Popov, 1959" listing in synonymy "*Ergenica cimlanica* Zhichenko, 1952 (nom. nud.)". The present reference may be the validating one for the genus.

As noted by Ctyroky (1987, Vydaia Univ. Karlova, Praha, pp. 75-77) a number of authors, including Korobkov (1968), Merklin (1974), and Ctyroky (1972) believe this genus is more closely related to the family Cultellidae in the Solenacea, than it is to the Veneracea.
†**URBNISIA** Gontscharova, 1981, Paleont. Zhurn., 1981 (2): 32

CORBULIDAE - 181, 252

†**JURASSICORBULA** Fürsich, 1981, Neues Jahrb. Geol. Palaont., MH, 1981 (12): 738
†**PEBASIA** Nuttall, 1990, Bull. Brit. Mus. Nat. Hist, (Geol), 45 (2): 315
†**SUROBULA** Zinsmeister, 1988, in Feldmann & Woodburne (eds.) G.S.A. Mem. 169: 280

HIATELLIDAE - 185, 252

PANOPEA Menard de la Groye, 1807, validated: ICZN Op. 1414 *Panope* & *Glycimeris* placed on Official Index of Invalid Names (see 1980 edition, pp. 180, 181).

PHOLADIDAE - 187, 252

NIPPONOPHOLAS Okamoto, 1987, Venus, Jap. Jour. Malac., 46 (2): 134 (Japanese), 135 (English)
†**TAIWANOBARNEA** Wang, 1983, Bull. Central Geol. Surv. Taiwan, 1983 (2): 121

XYLOPHAGINAE - 190

XYLOREDO Turner, 1972, Breviora, Mus. Comp. Zool., (397): 3

TEREDINIDAE - 191

CESARIANA Munari, 1977, Lavori Soc. Venez. Sci. Nat., 2: 12

MEGALODONTIDAE - 193, 253

†**AMPEZZANIA** Alassinaz & Zardini, 1977, Rev. Ital. Paleont. Strat., Mem. 15: 121
†**PROTOMEGALODON** Voskova, 1971, Zapiski Leningr. Gorn. Inst., 59 (2): 103

REQUIENIIDAE - 195

†**RUTONIA** Yang, Nie & Wu, 1982, Acta Geol. Sinica, 56 (4): 297 (Chinese), 300 (English)

CAPROTINIDAE - 196, 253

†**GLOSSOMYOPHORUS** Masse, Skelton & Sliskovic, 1984, Geobios, 17 (6): 726
†**PARAPACHYTRAGA** Yanin, 1986, Paleont. Zhurn., 1986 (1): 113

HIPPURITIDAE - 197, 254

†**PSEUDOPIRONAEA** Bilotte, 1982, Bull. Soc. Hist. Nat. Toulouse, 117 (1-4) "1981": 113
†**TETRAVACCINITES** Bilotte, 1981, Geobios, 14 (1): 126

RADIOLITIDAE, Subfamily Uncertain - 200

†**BALABANIA** Karacabey-Oztumer, 1980, Turkiye Jeol. Kur. Bult., 23 (1): 80
†**BRANISLAVIA** Sladic-Trifunovic, 1981, Geol. Anali Balk. Poluost, 43-44: 208
†**FUNDINIA** Sladic-Trifunovic & Pejovic, 1977, Geol. Anali Balk. Poluost., 41: 221
†**HAYATIN** Karacabey-Oztumer & Selcuk, 1983, Bull. Min. Res. Explor. Inst., Ankara: (95-96) "1980-1981": 99
†**KURTINIA** Karacabey-Oztumer, 1980, Turkiye Jeol. Kur. Bult., 23 (1): 84
†**LATTENBERGITES** Lupu, 1987, Dari de Seama ale Sedintelor, 72-73: 72

ORTHONOTIDAE - 202, 255

†**BREVIORTHONOTA** Krasilova, 1979, Biv. Moll. of Mangazeiski, Doldorski, & Ketski Horizons: Geol. In-ta, Akad. Nauk, Moscow: 119

GRAMMYSIIDAE - 202, 255

†**ANDINODESMA** Rehfeld & Mehl, 1989, Palaeont. Zeitsch., 63 (3-4): 268
†**ASKETOMORPHA** Hoare, Heaney & Mapes, 1989, Jour. Paleont., 63 (5): 598
†**ECTOGRAMMYSIA** Hoare, Heaney & Mapes, 1989, Jour. Paleont., 63 (5): 596
†**GLYPTOCONCHA** Zhang & Pojeta, 1986, Jour. Paleont., 60 (3): 674
†**LOPHOPROTHYRIS** Hoare, Heaney & Mapes, 1989, Jour. Paleont., 63 (5): 596
†**MANANKOVIA** Astafieva-Urbaitis, 1983, New Species Fossil Inverts. Mongolia: Geol. In-ta, Akad. Nauk SSSR: 71
†**RAGOZINIA** Muromzeva, 1984, in Muromzeva & Guskov, Permian Marine Deposits Bivalve Moll. Soviet Arctic: Nedra, Leningrad: 113
†**VARVAROVELLA** Sergeeva, 1981, Paleont Zhurn., 1981 (3): 132 [n.n. pro *Polinia* Seergeeva, 1966, non Demarest in Chenu, 1859]

†**VERCHOJANOGRAMMYSIA** Muromzeva, 1984, in Muromezva & Guskov, Permian Marine Deposits Bivalve Moll. Soviet Arctic: Nedra, Leningrad: 112

MEGADESMIDAE - 203, 256

†**PRAEMYONIA** Astafieva-Urbaitis, 1988, Paleont. Zhurn., 1988 (2): (p. ?, not seen)

PHOLADOMYIDAE - 204, 256

†**AGRAWALIMYA** Singh, Jaitly & Pandey, 1982, Veliger, 24 (3): 273
†**COLORADOMYA** Petuch, 1988, Bull. Paleomalacol., 1 (3): 44
†**DULUNOMYA** Astafieva-Urbaitis & Dickins, 1984, Paleont. Zhurn., 1984 (3): 37
†**INDOMYA** Jaitly, 1986, Veliger, 28 (4): 457

SINODORIDAE New Family Pojeta & Zang, 1984
[insert after Pandoridae - 207]

†**SINODORA** Pojeta & Zhang, 1984, Jour. Paleont., 58 (4): 1021

LATERNULIDAE - 207, 256

†**PLANARIOMYA** J. Chen & Yu, 1980, Acta Palaeont. Sinica, 19 (5): 364 (Chinese), 366 (English)

PERIPLOMATIDAE - 209, 256

CRICOPLOMA Bernard, 1989, Venus, Jap. Jour. Malac., 48 (1): 4 [also as *Gricoploma,* p. 4]
SEPTENTRIOPLOMA Bernard, 1989, Venus, Jap. Jour. Malac., 48 (1): 5
TAKASHIA Bernard, 1989, Venus, Jap. Jour. Malac., 48 (1): 9

THRACIIDAE - 209

PSEUDOCYATHODONTA Coan, 1990, Veliger, 33 (1): 43
SKOGLUNDIA Coan, 1990, Veliger, 33 (1:) 40

POROMYIDAE - 211

PERLAPOROMYA Scarlato & Starabogatov, 1983, Syst. Biv. Moll. Septibranchia; in Moll. Syst., Ecology; Akad. Nauk SSSR: 11

CUSPIDARIIDAE - 212, 257

ALLENINEAERA Scarlato & Starabogatov, 1983, Syst. Biv. Moll. Septibranchia; in Moll. Syst., Ecology; Akad. Nauk, SSSR: 13
BATHYNEAERA Scarlato & Starabogatov, 1983, Syst. Biv. Moll. Septibranchia; in Moll. Syst., Ecology; Akad. Nauk, SSSR: 13
BIDENTARIA Allen & Morgan, 1981, Phil. Trans. Roy. Soc. London, (B, Biol. Sci.) 294 (1073): 499
EDENTARIA Allen & Morgan, 1981, Phil. Trans. Roy. Soc. London, (B, Biol. Sci.) 294 (1073): 497
LABROMYSA Bernard, 1989, Venus, Jap. Jour. Malac., 48 (2): 64
NORDONEAERA Okutani, 1985, Venus, Jap. Jour. Malac., 44 (3): 147
OCTOPORIA Scarlato & Starabogatov, 1981, Syst. Biv. Moll. Septibranchia; in Moll. Syst., Ecology; Akad. Nauk, SSSR: 13
PROTOCUSPIDARIA Allen & Morgan, 1981, Phil. Trans. Roy. Soc. London, (B, Biol. Sci.) 294 (1073): 496
SEMICARDIOMYA Scarlato & Starabogatov, 1983, Syst. Biv. Moll. Septibranchia; in Moll. Syst., Ecology; Akak. Nauk, SSSR: 13
SOYOMYA Okutani, 1985, Venus, Jap. Jour. Malac., 44 (3): 147

VERTICORDIIDAE - 213, 257

ALLENICORDIA Scarlato & Starabogatov, 1983, Syst. Biv. Moll. Septibranchia; in Moll. Syst., Ecology; Akad. Nauk, SSSR: 10

ANGUSTEBRANCHIA Ivanova, 1977, Trudi In-ta Okeanol., Akad. Nauk SSSR, (108): 177
DALLICORDIA Scarlato & Starabogatov, 1983, Syst. Biv. Moll Septibranchia; in Moll. Syst., Ecology; Akad. Nauk, SSSR: 12
LATEBRANCHIA Ivanova, 1977, Trudi In-ta Okeanol., Akad. Nauk, SSSR, (108): 189
RECTILYONSIELLA Scarlato & Starabogatov, 1983, Syst. Biv. Moll. Septibranchia; in Moll. Syst., Ecology; Akad. Nauk, SSSR: 10
Spinolyonsiella Scarlato & Starabogatov, 1983, Syst. Biv. Moll. Septibranchia; in Moll. Syst., Ecology, Akad. Nauk, SSSR: 10 [= *Allogramma* Dall, 1903]

CLAVAGELLIDAE - 214, 257

†**ASCAULOCARDIUM** Pojeta & Sohl, 1987, Paleont. Soc. Mem. 24: 57

MYODAKRYOTIDAE, New Family Tunnicliff, 1987
(Syst. Postion Uncertain, in Subclass PTERIOMORPHA)

†**MYODAKRYOTUS** Tunnicliff, 1987, Palaeontology, 30 (4): 684

CLASS, ORDER, & FAMILY UNCERTAIN - 215, 257

†**KENZIEANA** Liljedahl, 1989, Palaont. Zeitsch., 63 (3-4): 230
†**LISPOCHLAMYS** --- Listed by Yin, 1989, Acta Palaeont. Sinica, as Jurassic bivalve from Yanshiping Gr., southern Quinghai; no mention of species.
†**MIAGKOVIA** Rozov, 1980, Byull. Mosk. Obshch., Isp. Prir. (Otd. Geol.), 55 (2): 91
†**NARONIA** Sliskovic, 1987, Glasnik Mus. Bosne Hercog., Prirodne Nauke, (NS) 25-26: 3
†**POLSAKIA Sliskovic**, 1982, Glasnik Mus. Bosne Herceg., Prirodne Nauke, (NS) 21: 10
†**PSEUDOMYONA** Runnegar, 1983, Mem. Assoc. Australasia Palaeont., 1: 40 [referred to Tuarangiidae]
†**TUARANGIA** MacKinnon, 1982, Jour. Paleont., 56 (3): 591 [placed in new superfamily Tuarangiacea, family Tuarangiidae - "probably bivalved monoplacophoran" fide Runnegar & Bentley, 1983, Jour. Paleont., 57 (1): 92]
†**UGARELLA** Polsak & Sliskovic, 1987, Glasnik Mus. Bosne Herceg., Prirodne Nauke, (NS) 25-26: 16
†**YANGTZEDONTA** Yu, 1985, Acta Micropalaeont. Sinica, 2 (4): 402 (Chinese), 406 (English) ["perhaps most primitive bivalve, ? Pterineidae"]

BIVALVIA ? - 217

†**JELLIA** Li & Zhou, 1986, Scientia Geol. Sin., 1986 (1): 41
†**PALEOLITHOPHOLAS** Badve & Chare, 1984, Bio-Vigyanam, 10 (2): 168 [Holocene trace fossil]
†**PETROXESTES** Wilson & Palmer, 1988, Jour. Paleont., 62 (2): 307

PRAELAMELLIDONTACEA, New Superfamily
PRALAMELLIDONTIDAE, New Family, Zhang, 1980

†**HABEINELLA** Zhang, 1980, Bull. Chinese Acad. Geol. Sci., (8) 1 (1): 14
†**PRAELAMELLODONTA Zhang, 1980, Bull. Chinese Acad. Geol. Sci., (8) 1 (1): 7**
†**XIANFENGOCONCHA** Zhang, 1980, Bull. Chinese Acad. Geol. Sci., (8) 1 (1): 9

CYCLOCONCHOIDIDAE, New Family, Zhang, 1980

†**CYCLOCONCHOIDES** Zhang, 1980, Bull. Chinese Acad. Geol. Sci., (8) 1 (1): 12

["Most ... Cambrian fossils which have been referred to the Bivalvia (e.g. ... Zhang, 1980) are certainly or probably deformed brachiopods (or) rostroconchs": Runnegar & Bentley, 1983, Jour. Paleont., 57 (1): 73]

ROSTROCONCHIA, Incertae - 260

†**CASSOWARIOIDES** Johnston & Chatterton, 1981, Canadian Jour. Earth Sci., 20 (5): 852
†**NEHEDIA** Johnston & Chatterton, 1983, Canadian Jour. Earth Sci., 20 (5): 854

ERRATA

Page	Line	Correction
4	50	Italicize *Spinula* - add [non Herrich-Shaeffer, 1856 (Lepid.)]; see *Acutispinula*
17	37	Italicize *Barbatiella* - add [invalid, ICZN Art. lld - published in synonymy]
17	52	*Paranoetia* Thiele is valid, not invalidated by *Barbatiella*.
32	1	Transfer *Kinerkaella* to Family Kinerkaellidae
32	3	Transfer *Kinerkaellina* to Family Kinerkaellidae
34	11	Add "[1820]" following "1847"
42	51	*Parainoceramus* - add [invalid, no type designated]; Cox, 1954, Proc. Malac. Soc. London, 31 (2): 47
60	5	Delete "*Hemiplicatula* Deshayes, 1861" - referred to Bivalved Gastropod family Juliidae: see Le Renard, 1980, Bull. Inform. Geol. Bassin Paris, 17 (2): 24, 25.
72	13	Change "Weir in Vokes, 1967" to "Weir, 1969". [ICZN Code, Art. 13(a)(ii) requires all names proposed after 1930 to be accompanied by a description or bibliographic reference to such a description.
72	19	Delete "(Kiev)"
78	6	Change *Richtofenia* to *Richthofenia*
82	37	Change *Protopomida* to *Propotomida*
96	1	Add (as *Caelatura*, p. 268)
125	42	Change "Chavan in Vokes, 1967" to "Chavan, 1969" - see note relative to p. 72, line 13 (above)
138	21	Add "1969" after "Keen [1894]"
147	17	Transfer *Hemidonax* to Cardiidae, Subfamily Hemidonacinae Iredale & McMichael, 1962
151	35	Change "p. 282" to p. 284
154	24	Add "in Turton" following "Gray"
164	8	Transfer *Yokoyamaina* to Protocardiinae, p. 129 (see Hayami, 1972, Geol. Palaeont. S. E. Asia, 10: 204
179	40	*Rupellaria* - valid; delete "[= *Petricola* Lamarck, 1801]"
186	30	Delete "application is pending for its entombment in the Official Index of the International Commission under suspension of the Code" - add: rejected, Opinion 1414
186	57	Add - [Rejected, Opinion 1414]
187	2	Add - [Valid, Opinion 1414]
189	7	Change "1953" to 1954
190	7	Change "*Schroeteria*" to *Schroteria*; delete "[original as *Schroteria*]"

211	32	*Leiopistha* - delete Dalton, 1878 reference: substitute "White, 1874, Explor. & Surv. West 100th Meridian, Prelim. Rept., Invert. Fossils: 26"
211	45	*Psilomya* - delete Meek, 1876, reference; substitute "White, 1874, Explor. & Surv. West 100th Meridian, Prelim. Rept., Invert. Fossils: 26"
216	44	Transfer *Planktomya* from "Class, Order & Family Uncertain - Tertiary & Recent Genera" to ?Family Sportellidae (pages 115 & 241)
220	2	Change "1894" to 1893
220	32	Change "366-E" to 306-E
221	22	Delete "?" after *Vnigriella,* + "p. ? (not seen)" - add p. 30
221	34	*Crassoleda* - delete "p. ? (not seen)" - add p. 27
221	36	*Epacroleda* - delete "p. ? (not seen)" - add p. 29
221	45	*Praeportlandia* - delete "p. ? (not seen)" - add p. 32
221	50	*Sachalinella* - delete "p. ? (not seen)" - add p. 31
223	18	Change "1938" to 1937
225	8	*Shikamaia* - delete "p. ? (not seen)" - add p. 28
225	12	Transfer *Abakaniella* from Myalinidae to Family Prilukiellidae, p. 72
225	37	*Mytilidesmatella* - delete "p. ? (not seen)" - add p. 13
225	41	Add - non Bleeker, 1863
225	48	*Trabeculatia* - delete "p. ? (not seen) - add p. 15
226	32	Add "[ICZN 473]" following "1881"
226	49	Delete *Parinoceramus* entry (see note above regarding p. 42, line 51)
227	32	Change "1818" to 1819
228	15	Change "*Loemelella*" to *Loemmelella*
228	18	Change "*Monssonella*" to *Monnssonella*
229	14	*Lissochlamis* - delete "p. ? (99-102, not seen)" - add p. 102
229	35	*Macrochlamis* - delete "p. ? (99-102, not seen)" - add p. 101
230	28	Add "[ICZN 492]" following "1953"
231	33	Add "[ICZN 356]" following "1815"
231	34	Change "Ostreidae" to "Ostreinae"
232	8, 10, 12	Change "Lafèvre" to Lefèvre
233	12	Change "Eager" to Eagar
233	4, 10, 43, 46, 47	Change "Amalitizki" to Amalitzky

234 1 Ferganoconchidae - change "1961 [1956]" to 1956

234 10 Pseudocardiniidae - change "1960" to 1961

234 24 Margaritiferidae - add "[ICZN 495]" following " 1940"

234 16-23 Transfer *Itatia, Sibirinaia* & *Tchulymiconcha* from Pseudocardiniidae to Family Margaritiferidae

234 43 Unionidae - add "[ICZN 495]" following "1828"

238 6 *Unionina* - delete "p. ? (not seen)" - add p. 475; delete "or *Unionites* Wissmann, 1841"

240 34 Erycinidae - change "1859" to 1850

241 24 Add "Thiele, 1934" following NEOLEPTONIDAE

241 28 Add "[1895] ICZN Code, Art 40" following "1959"

241 29 Add "[1895]" following "1959"

242 34, 35 Change "1884" to 1844

243 11 Change "*Tribonocrassatella*" to *Trigono-*"

243 15 *Myophoriaemorphis* - delete "p. ? (not seen)" - add "p. 17 (Russian) 25 (French)"

243 36 Change "*Dochmiocardia*" to *Dochmocardia* and vol. "53" to 52

245 16 Delete reference - proposed as group name "Inaequicostates"

245 41 Change "ZENATRIINAE" to ZENATIINAE

248 48 *Kelliella* - delete "p. ? (not seen)" - add p. 207

252 9 Change "1842" to 1824

252 33 Transfer *Naucitoria* and reference to Teredinidae Subfamily Bankiinae, p. 192

252 34 Change "*Opterochasma*" to *Opertochasma*

254 19 Hippuritidae - add "[ICZN 613]" following "1848"

254 34 Change "*Bystrikhya*" to *Bystrichia*; delete "p.? (not seen)" - add p. 36

255 6 *Orestella* - delete "1980, in press" - add 1980 [1982], Dari Seama Sed. Inst. Geol. Rom., 67 (3) 1979-1980: 83 [n.n. pro *Orestia* Lupu, 1973]

257 9 Change "1870" to 1871

257 11, 13 Add "[invalid, no type design.]" following references to *Angustebranchia* and *Latebranchia*

257 39 *Antactinodion* is valid as of Guo, 1980, who creates a "Family Actinodiontidae" in Nuculanacea to also include *Dysodonta* Mansuy, 1913 (see p. 3)

257 46 *Inneiana* - delete "p. ? (not seen)" - add p. 13

274 28 *Egerella* - change "245, 246" to 247

279 19 *Harpax* - change "150" to 151

289 10 Change "*Nipponopected*" to - *pecten*

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REVIEW

DINOSAURS DOWN UNDER AND OTHER FOSSILS FROM AUSTRALIA, by Caroline Arnold, photographs by Richard Hewett. Claron Books, New York, 1990, ISBN 0-89919-814-7, 48 pages.

This book is designed to inform young readers on how scientific material is received and set up for exhibit in a museum. It then goes on to discuss the significance of the exhibit material. The exhibit: *Kadimakara: Fossils of the Australian Dreamtime,* a collection of Australian vertebrate fossils ranging in age from Early Paleozoic to Pleistocene-Holocene time, was displayed in the Los Angeles County Museum.

The author introduces many significant concepts in this short book but does not carry through on them. This book would work best for the young reader if read with an informed adult who could fill in the many informational gaps. The brief descriptions of the various vertebrate specimens convey little information but they are somewhat offset by the large color photographs of the exhibited material. However, the photo illustrations are clearly set in the context of the exhibit and are not in a mode to convey maximum information about the specimens. The title is somewhat misleading, only three pages are directly concerned with dinosaurs and most of the book is concerned with fossil reptiles, birds, and marsupials.

On balance the book is interesting and well illustrated but the young reader is likely to miss much of its significance unless there is outside intellectual input.

R.L.P.

ON THE OCCURRENCE OF THE GASTROPOD GENUS *CASSIS* IN THE ESMERALDAS FAUNA, NORTHWESTERN ECUADOR

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In his seminal treatment of the Panama Land Bridge as a sea barrier, Woodring (1966) coined the now-familiar term "paciphile" for those molluscan genera and/or species that, during the Tertiary, lived on both sides of the Tropical American landmass, but today are living only on the Pacific side. At that time he listed 43 genera or subgenera classified as paciphiles; predicting, however, that some would be eliminated from the list as living representatives were discovered in the western Atlantic. In contrast, he cited only four "caribphile" genera, those that survive in the Caribbean but are extinct in the eastern Pacific. Time has proved his prediction correct and perhaps five of the formerly paciphile genera have been eliminated from his list, nevertheless the overwhelming number of paciphile genera, in contrast to caribphile genera, remains intact.

In his scant list of caribphile genera he included the gastropod genus *Cassis* Scopoli, 1777, noting that the only eastern Pacific fossil occurrence of the genus is in the Imperial Formation of southern California (1966, p. 430). The Imperial fauna is so like the Caribbean fauna that it barely counts toward documenting an eastern Pacific fossil record for any taxa occurring in it.

Woodring also noted that many of the paciphile genera had no fossil record on the Pacific side due to the smaller area of fossiliferous deposits in the eastern Pacific part. One of the rare occurrences of well-preserved late Tertiary mollusks is found in the Esmeraldas beds, upper Onzole Formation, of Early Pliocene age (Zone N.19) in northwestern Ecuador.

If Woodring is correct in his assessment then there should be a marked similarity between the Pliocene faunas of the Atlantic and Pacific. In an earlier study of the Esmeraldas Muricidae (Vokes, 1988), I was disappointed to discover that the correlation with the Caribbean fauna was much less than hoped for. In the Esmeraldas beds only seven of 21 species of Muricidae also occur in the Pliocene of the western Atlantic, although 12 have unmistakable Atlantic ancestry.

Thus, it was a pleasant surprise to learn of a specimen of the genus *Cassis* in the paleontological collections of the British Museum (Natural History), which was originally collected by C. Roger Bristow, British Geological Survey, at Camarones, Ecuador, from the road-cut that is the equivalent of TU locality 1399. It was tentatively identified as *Cassis sulcifera* Sowerby, 1850, a species originally described from the Dominican Republic.

In the Esmeraldas Muricidae study it was discovered that, in contrast to my expected correlation with the Late Miocene-Early Pliocene Cercado/Gurabo Formation of the Dominican Republic, only one species (*Typhis alatus* Sowerby, 1850) was found to be common to both, but three Esmeraldas muricid species also occur in the the Floridian Pinecrest and Caloosahatchee formations.

Therefore, what species of *Cassis* is this specimen from Ecuador? Various species have been reported from Tertiary localities through the western Atlantic. The most commonly reported is the Dominican *Cassis sulcifera* (pl. 2, fig. 1). This is a relatively small species, the largest specimen seen is that figured by Maury (1917, pl. 18[44], fig. 1), from the Gabb Collection, which measures about 100 mm in length. In our collections from the Dominican Republic the largest example is 95 mm but most examples are 80 mm or less. As Maury noted (1917, p. 110[274]): "This fine shell exhibits such diverse aspects in youth and old age, as to appear, without a connecting series, two different species" (see Abbott, 1968, pl. 29, for four very different individuals in the Gabb Collection at the Academy of Natural Sciences of Philadelphia, no. 2593). Maury reported it from both the Cercado and Gurabo formations, and in our collecting we have taken it at almost every locality in the "middle depths," *i.e.*, the deeper portions of the shallow-water Cercado Formation and the shallower portions of the deep-water Gurabo Formation.

Given the great variability demonstrated by this species, one wonders whether it is possible to separate the Dominican species from that one occurring in the Chipola For-

mation of northwestern Florida named *Cassis delta* by Parker (1948, p. 91, pl. 6, fig. 1). The major distinguishing criterion seems to be the larger size of *C. delta*. We have numerous examples from the Chipola Formation, and most are about 135 mm in length, comparable to the holotype. In addition, in the adult examples of *C. delta* there is a tendency to lose the lirae on the parietal shield. In young examples the two species are indistinguishable in terms of number of lirae, but in mature examples the parietal area of *C. delta* is nearly smooth.

In the most recent review of *Cassis sulcifera,* Abbott (1968, p. 53) included *C. flintensis* Mansfield, 1940, from the Oligocene Flint River and Chickasawhay formations, Georgia and Mississippi respectively, in the synonymy, but this is clearly incorrect. The Mansfield species is extremely cancellate and appears to be closely related to the European *C. mamillaris* Grateloup, 1827, from correlative beds in France (see Abbott, 1968, pl. 32, for illustrations of several forms of this species). Rutch's reference (*in* Stainforth, 1948, p. 1311) to *Cassis* cf. *sulcifera* from the Morne Diablo Limestone of Trinidad may refer to the Chipolan *C. delta,* which is the same Early Miocene age as the Morne Diablo Limestone (see H. E. Vokes, 1982, p. 51).

The Recent *C. flammea* (Linné, 1758) was reported by Gabb (1881, p. 356) from the Pleistocene Moín Formation of Costa Rica. Gabb's specimen (ANSP 3368) is a large (120+ mm), incomplete shell, far larger than any known examples of *C. sulcifera,* and in overall shape much like *C. flammea;* however, the numerous juveniles in the Tulane collections from the Moín Formation in the vicinity of Puerto Limón (most from TU 954) have the color pattern on the edge of the pareital shield preserved (see pl. 2, fig. 2a) and they possess the strong brown blotches characteristic of *C. tuberosa* (Linné, 1758). The two Recent species, *C. flammea* and *C. tuberosa* are extremely close in morphology and are separated only by the reticulate surface sculpture of *C. tuberosa* and by the presence of the brown markings on the *apertural* side of the outer edge of the parietal shield (both species have blotches on the adapertural side of the outer lip). The specimens from the Early Pleistocene Bowden Formation, Jamaica, identified by Woodring (1928, p. 304, pl. 19, figs. 5, 6) as *C. sulcifera* also have these brown blotches preserved (material in our collection from locality TU 705) and are the same undescribed species as that in the Moín Formation.

However, even extended treatment with sodium hypoclorite bleach (see Vokes and Vokes, 1968, p. 76, for discussion of this treatment to induce fluorescent color patterns) failed to bring out any trace of these blotches on specimens of *C. sulcifera.* Indeed, it would appear that the entire parietal shield was brown. Given the overall morphology of the shell, with the tendency to expand greatly the parietal shield in gerontic individuals, it seems probable that *C. sulcifera* gave rise to the Recent *C. madagascariensis* Lamarck, 1822, which has no brown blotches on the margin of the aperture but only a large colored area in the vicinity of the apertural opening.

In the Florida Pliocene there is another species described as *C. floridensis* by Tucker and Wilson (1932, p. 11[49], pl. 2[6], figs. 2, 5; pl. 5[9], fig. 2). The original holotype specimen came from the Pinecrest Beds at Acline, Florida (= locality

PLATE 1

Figure

1. *Cassis* sp. cf. *C. subtuberosa* Hanna (X 1)
   BM(NH) Palaeont. Dept. GG 22469; length (incomplete) 53.8 mm, diameter (incomplete) 50.2 mm, height (incomplete) 44.5 mm.
   Locality: CRB 284; 0°59′N, 79°34′W, Punta Camarones, Ecuador. Esmeraldas Beds.
   (Figures 1d-f whitened to show details of ornamentation.)
2. *Cassis delta* Parker (X 1)
   USNM 453851; length (incomplete) 65.2 mm, diameter 51.5 mm.
   Locality: TU 70, Chipola Formation, Florida.
   (Color pattern as shown by ultra-violet light.)

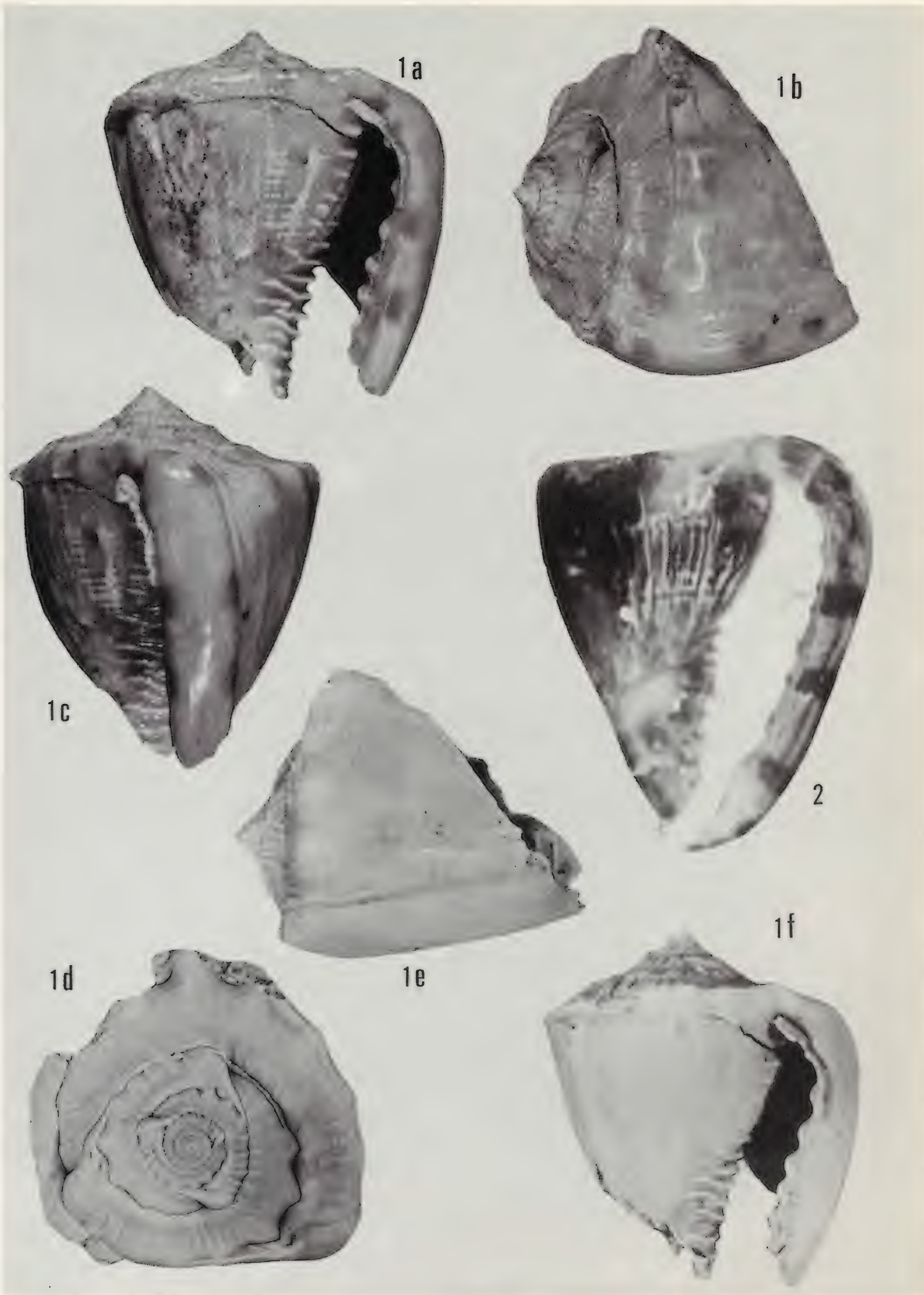

PLATE 1

TU 200), and we have several specimens from other Florida localities, all in the Pinecrest Beds. If, as noted above, the strongest affiliations between the Esmeraldas beds and the western Atlantic fauna are found in Florida, might the Esmeraldas specimen be an example of *C. floridensis*? It is unlikely, as the Florida species is easily recognized by the strongly cancellate surface ornamentation; so strong that it is often visible through the parietal shield (see Petuch, 1988, unnumbered illustration on p. 103). Adults attain a much larger size than *C. sulcifera,* but the juveniles with their cancellate shells are readily separable as well. No specimens of *C. floridensis* show the typical brown markings on the edge of the outer lip and it is probable that *C. floridensis* is the ancestor of the living *C. spinella* Clench, 1944, a species found today in the southern Florida-Yucatan region.

The Imperial Formation species was named *C. subtuberosa* by Hanna (1926, p. 444, pl. 20, fig. 8; pl. 29, figs. 2, 3 – refigured by Abbott, 1968, pl. 25). The material is poorly preserved, as is typical of the Imperial Formation, but the shell shape is closest to the Caribbean *C. flammea.* The Ecuadorian specimen, although badly broken, shows a general shape that is very close to that of *C. subtuberosa.* The color pattern on the Ecuadorian specimen is well-preserved (pl. 1, figs. 1a-c) and shows strong blotches on the apertural side of the outer lip in the manner of *C. tuberosa.* However, the shell is smooth (pl. 1, fig. 1e), lacking the reticulate surface of *C. tuberosa.* With the limited material available, positive identification is not possible but it seems most closely allied with the Imperial species and Hanna apparently was correct in his affiliating the Imperial shell with the living *C. tuberosa.*

In summary, we find that, although *Cassis sulcifera* has been reported from numerous formations throughout the Neogene of the Caribbean, it is confined to the Cercado and Gurabo formations of the Dominican Republic. With its non-colored apertural lip, it is presumed to be ancestral to the living *C. madagascariensis.* In the Floridian Pliocene, *C. floridensis* is the species present and it is presumed to have given rise to the living *C. spinella.* In the Pleistocene Bowden and Moín formations, there is another as-yet undescribed species, presumed to be ancestral to the living *C. tuberosa.*

On the Pacific coast the species of *Cassis* found in the Pliocene of Ecuador cannot be referred to any known Caribbean species and is probably the same as *C. subtuberosa,* described from the Pliocene Imperial Formation of California. The Early Miocene Chipola Formation species *Cassis delta* under ultra-violet light shows marked color bands on the apertural lip (pl. 1, fig. 2), and it is presumed to be the predecessor of this Pacific branch of the *C. tuberosa* lineage, indicating, as noted previously (Vokes, 1988, p. 12), that most of the elements of the Pacific fauna were in place before the Pliocene. The fossil record of the genus *Cassis* in the New World is obviously very incomplete but much richer than has been recognized previously.

ACKNOWLEDGEMENTS

I wish to thank Patrick Nuttall and John Cooper, Department of Palaeontology, British Museum (Natural History), for the loan of the Esmeraldas specimen, and Mr. and Mrs. William D. Pitt, Sacramento, California, for calling it to my attention.

PLATE 2

Figure

1. *Cassis sulcifera* Sowerby (X 1)
   USNM 453852; length 59.0 mm, diameter 44.8 mm, height 43.0 mm.
   Locality: TU 1420, Cercado Formation, Dominican Republic.
2. *Cassis* sp. cf. *C. tuberosa* (Linné) (X 1)
   USNM 453853; length 54.0 mm, diameter 41.3 mm, height 37.6 mm.
   Locality: TU 956, Moín Formation, Costa Rica.

(Figure 2a not whitened to show color pattern; all others whitened to show details of ornamentation.)

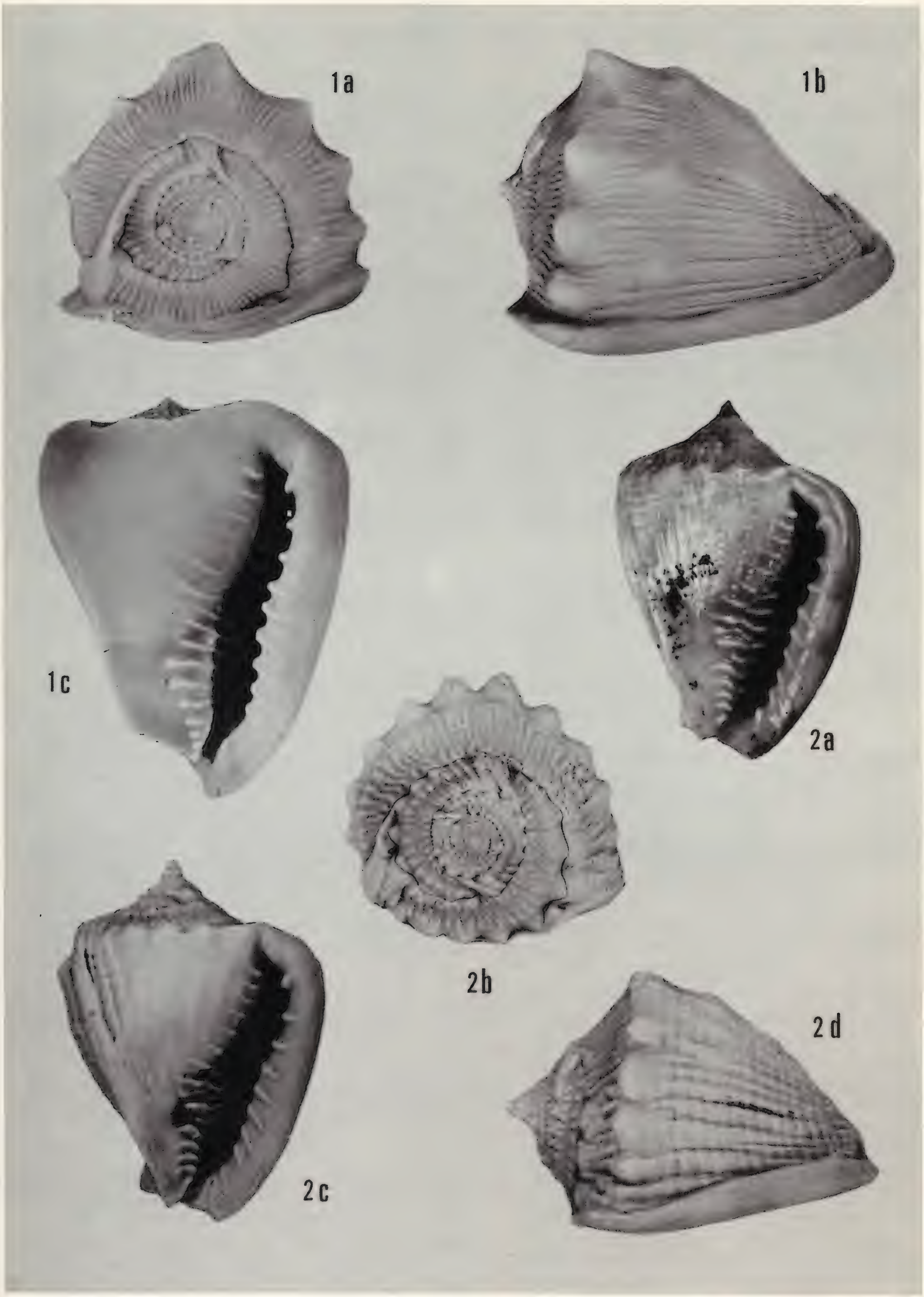

PLATE 2

LOCALITY DATA

The following are Tulane University fossil locality numbers:

70. Chipola Fm., Tenmile Creek, at bridge of Florida Highway 73 (NW 1/4 Sec. 12, T1N, R10W) Calhoun Co., Florida.
200. Pinecrest Beds, borrow pits about one mile southwest of Acline (Sec. 29, T41S, R23E), Charlotte Co., Florida.
705. Bowden Fm., type locality, Bowden, just east of Port Morant, Parish of St. Thomas, Jamaica.
954. Moín Fm., hill cut immediately behind Standard Fruit Company box factory, just west of cemetery at Pueblo Nuevo, about 2 km west of Puerto Limón, Costa Rica.
956. Moín Fm., hillslope behind Baptist church on road from Puerto Limón to Pueblo Nuevo, about .75 km east of Pueblo Nuevo, Costa Rica.
1399. Esmeraldas Beds, roadcut on west side of village of Camarones, which is 20 km (by road) east of bridge over Río Esmeraldas, at Esmeraldas, Prov. of Esmeraldas, Ecuador.
1420. Cercado Fm., Arroyo Bellaco, which is a tributary of the Río Cana from the east; first canyon above the ford at Las Caobas Adentro, 3 km southwest of Las Caobas, Dominican Republic.

LITERATURE CITED

ABBOTT, R. T., 1968, The helmet shells of the world (Cassidae). Part 1: Indo-Pacific Mollusca, v. 2, no. 9, p. 7 [12-409]-202 [12-716], 186 pls.

GABB, W. M., 1881, Descriptions of new species of fossils from the Pliocene Clay Beds between Limon and Moen, Costa Rica, together with notes on previously known species from there and elsewhere in the Caribbean: Acad. Nat. Sci. Phila., Jour., (Ser. 2) v. 8, no. 4, p. 349-380, pls. 45-47.

HANNA, G. D., 1926, Paleontology of Coyote Mountain, Imperial County, California: California Acad. Sci., Proc., (Ser. 4) v. 14, no. 18, p. 427-503, pls. 20-29, 1 text-fig.

MAURY, C. J., 1917, Santo Domingo type sections and fossils; Pt. 1, Mollusca: Bulls. Amer. Paleontology, v. 5, no. 29, p. 165-415, pls. 27-65, 1 map.

PARKER, J. D., 1948, A new *Cassis* and other mollusks from the Chipola Formation: Nautilus, v. 61, no. 3, p. 90-95, pl. 6.

PETUCH, E. J., 1988, Neogene history of tropical American mollusks. Coastal Educ. and Resh. Found. (CERF), Charlottesville, Virginia, 217 p., 39 pls., 23 (+ 7 unnumbered) text-figs.

STAINFORTH, R. M., 1948, Description, correlation, and paleoecology of Tertiary Cipero Marl Formation, Trinidad, B.W.I.: Amer. Assoc. Petrol. Geol., Bull., v. 32, no. 7, p. 1292-1330, 2 text-figs.

TUCKER, H. I., and DRUID WILSON, 1932, Some new or otherwise interesting fossils from the Florida Tertiary: Bulls. Amer. Paleontology, v. 18, no. 65, p. 39-62, pls. 5-9.

VOKES, E. H., 1988, Muricidae (Mollusca:Gastropoda) of the Esmeraldas beds, northwestern Ecuador: Tulane Stud. Geol. Paleont., v. 21, no. 1, p. 1-50, pls. 1-6, 15 text-figs., 1 table.

VOKES, H. E., 1982, Notes on the fauna of the Chipola Formation – XXV. On the occurrence of the genus *Rothpletzia* Simonelli (Mollusca:Gastropoda): Tulane Stud. Geol. Paleont., v. 17, no. 2, p. 51-54, 3 text-figs.

VOKES, H. E., and E. H. VOKES, 1968, Variation in the genus *Orthaulax* (Mollusca:Gastropoda): Tulane Stud. Geol., v. 6, no. 2, p. 71-79, pls. 1-3.

WOODRING, W. P., 1928, Miocene mollusks from Bowden, Jamaica; part 2, Gastropods and discussion of results: Carnegie Inst. Washington, Publ. 385, 564 p., 40 pls.

WOODRING, W. P., 1966, The Panama land bridge as a sea barrier: Amer. Phil. Soc., Proc., v. 110, no. 6, p. 425-433, 3 text-figs., 5 tables.

December 12, 1990

A NEW SPECIES OF *SPONDYLUS* (MOLLUSCA:BIVALVIA) FROM THE EOCENE OF ALABAMA

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Some time ago Royal D. Suttkus, Professor of Biology, Tulane University, collected the paired valves of a moderately sized specimen of *Spondylus* from the Middle Eocene Gosport Sand, at the exposure on Little Stave Creek, near Jackson, Clarke County, Alabama (locality TU 306). The only previous record of the genus from the Middle Eocene of the Atlantic and Gulf Coast fauna has been by Harris (1919, p. 29) who reported "a fragment of *Spondylus* of *dumosum* type but too imperfect for further characterization," from the "St. Maurice Stage" (Cook Mountain Formation) west of Winnfield, Winn Parish, Louisiana. A second, Early Eocene specimen from Hatchetigbee Bluff, Alabama, reported by Harris (1897, p. 234, pl. 12, fig. 11) as *Spondylus* sp., is an incomplete upper valve that shows no trace of spines on the radial ribs, which also are of a wholly different shape and number than are those in the present specimen.

This Early Eocene species has a surface ornament of alternating larger and smaller radial ribs but no spines, similar to that seen in the California Middle Eocene ("Domengine Stage") species named *Spondylus cliffensis* Hanna (1927, p. 278, pl. 32, figs. 2, 7). Another California Eocene species is *Spondylus carlosensis* Anderson, 1905, which has about nine of the radial ribs more enlarged but also has no spines. In contrast, the third known West Coast species, *S. bataquensis* Squires and Demetrion, recently described (1990, p. 385, figures 2.6-2.12) from Baja California Sur, is extremely spinose and is compared by the authors with the Mississippi Oligocene *S. dumosus* (Morton, 1834), their new species differing primarily in having more numerous radial ribs.

Family SPONDYLIDAE Gray, 1826
Genus SPONDYLUS Linné, 1758

Spondylus LINNÉ, 1758, Systema Naturae, ed. 10, p. 690.

Type species: *Spondylus gaederopus* Linné, 1758, by subsequent designation, Schmidt, 1818; Recent, "Mare Mediterraneo" (Linné, 1758) and "in the eastern Atlantic from Morocco to Senegal, and in the Atlantic Islands" (Dodge, 1952, p. 126).

Discussion: Species of *Spondylus* are perhaps the most variable of bivalved mollusks, as a result of the fixation of the right valve to the substrate. The nature and size of the material to which the shell becomes affixed strongly affects the shape of the valve and its ornamentation. If the shell area is held relatively high above the surrounding sediment the valve surface tends to develop normal spinose radial ribs, but if it is not above the sediment the valve surface commonly produces relatively well-spaced concentric laminae to hold itself above the softer sediments. Consequently, the lower valve in its early stages often has concentric laminae, which subsequently change to spines as the shell grows larger. But the upper valve will be uniformly spinose over the entire surface.

Similarly, as noted by Root (1988, p. 7) the strength of the currents in the water in which the specimens are living affects the "feathery, fingerlike projections" of the mantle margin that produce the external spines. Large, elongate spines can be produced only in quiet waters, for in swift currect areas the mantle projections cannot be held out long enough to permit the secretion of the large calcareous spines.

The result of these variable environmental factors has been the formation of highly diverse forms within each of the species and the assignment of many specific names to what are only infraspecific variations. Lamarck (1819), for example, described four species for variations of the form that we now know as *S. americanus* Hermann, 1791.

SPONDYLUS SUTTKUSI Vokes, n. sp.
Text-figures 1-3

Description: Shell of moderate size for the genus, slightly elongate-oval, with a small attachment area resulting in a regular outline. Surface of lower (right) valve is marked by regularly spaced lamellar foliations and lacks any radial ornamentation. The upper (left) valve is relatively low, arched; initially with about 15 primary radial ribs, which bear small narrow nodose projections, and usually with four secondary ribs between each pair of primary radials. With growth the projections on the primary ribs become moderately broad spines, the secondary ribs increase in strength and develop nar-

row needle-like ribs. In addition, narrow low tertiary radial ribs with sub-microscopic nodose projections appear. In the adult stage the primary and secondary ribs become almost equally strongly spinose, the tertiary ones develop relatively narrower projecting spines and three quaternary ribs are added in the interspaces, with the middle of the three tending to have smaller, relatively narrow spines, the marginal ones somewhat nodose and weak.

Holotype: USNM 450391.

Type locality: TU 306, Gosport Sand; Little Stave Creek, about 4 miles north of Jackson, Clarke County, Alabama.

Measurements of holotype: right (lower valve), height 65.2 mm, length 56.5 mm; left (upper valve), height 59.3 mm, length 56.5 mm; diameter of paired valves 29.6 mm.

Discussion: The two valves of this specimen display strikingly the different types of surface ornamentation developed in response to the environment. The lower valve is marked by strong concentric laminae, indicating its position on a relatively soft sediment bottom, and the upper valve is ornamented by numerous short, sharp spines, indicating a habitat of moderately strong current-flow. If the two valves had been taken separately they would have probably been assigned to two different species.

As noted above the only specimens previously known from the Eocene beds of the Atlantic and Gulf Coastal Plain have not been named. The named species are from the younger Oligocene beds: *Spondylus dumosus* (Morton, 1834), from the Red Bluff Formation, Alabama and Mississippi; *S. filiaris* Dall, 1916, from the Mint Springs Formation, Mississippi, and the Flint River Formation, Georgia; and *S. granulocostatus* Dockery, 1982, Red Bluff Formatiom, Alabama. All three have been figured by Dockery (1982, pl. 14, figs. 1-9 [*dumosus*]; pl. 15, figs. 1-3, 6, 7 [*filiaris*]; and pl. 15, figs. 4, 5 [*granulocostatus*]) and it may be seen that *S. dumosus* differs from *S. suttkusi* in having fewer, and relatively stronger primany and secondary ribs, ornamented by narrower, more elongate spines. *Spondylus filiaris* has almost no spinose ornamentation and *S. granulocostatus* has six of the radial ribs with heavy upturned spines, and between these numerous nodulose secondary radials.

LITERATURE CITED

DOCKERY, D. T., III, 1982, Lower Oligocene Bivalvia of the Vicksburg Group in Mississippi: Mississippi Bur. Geol., Bull. 123, 261 p., 62 pls., + appendix of 15 pls., 1 table, 48 text-figs.

DODGE, HENRY, 1952, A historical review of the mollusks of Linnaeus. Part 1. The classes Loricata and Pelecypoda: Amer. Mus. Nat. Hist., Bull., v. 100, Art. 1, 263 p.

HANNA, M. A., 1927, An Eocene Invertebrate fauna from the La Jolla Quadrangle, California: Univ. California Publ., Bull. Dept. Geol. Sci., v. 16, no. 8, p. 247-398, pls. 24-57.

HARRIS, G. D., 1897, The Lignitic Stage; Part I, Stratigraphy and Pelecypoda: Bulls. Amer. Paleontology, v. 2, no. 9, p. 193-294, pls. 7-20.

HARRIS, G. D., 1919, Pelecypoda of the St. Maurice and Claiborne Stages: Bulls. Amer. Paleontology, v. 6, no. 31, p. 1-268, pls. 1-59.

LAMARCK, J. B. M. de, 1819, Histoire naturelle des animaux sans vertebres, v. 6, pt. 1. Paris, 343 p.

ROOT, JOHN, 1988, Spine structure in *Spondylus americanus:* Amer. Conchologist, v. 16, no. 3, p. 7.

SQUIRES, R. L., and ROBERT DEMETRION, 1990, New Eocene marine bivalves from Baja California Sur, Mexico: Jour. Paleontology, v. 64, no. 3, p. 382-391, 4 text-figs.

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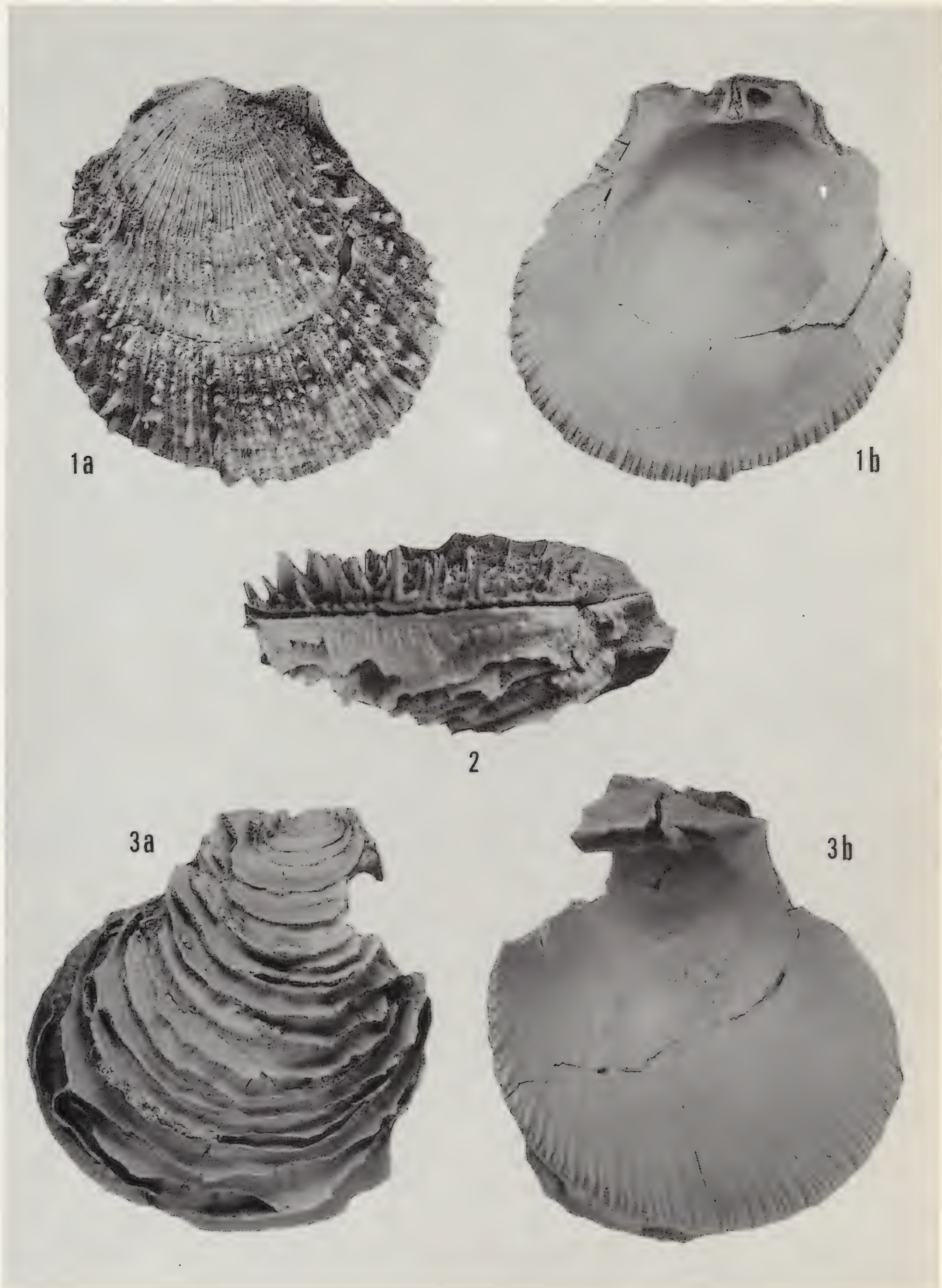
Text-figures 1-3. *Spondylus suttkusi* Vokes, n. sp.; USNM 450391 (holotype). Fig. 1, left (upper) valve; Fig. 2, paired valves; Fig. 3, right (lower) valve. (X 1)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NOTES ON THE FAUNA OF THE CHIPOLA FORMATION – XXXIII VARIATIONS ON A THEME – THE COLOR PATTERN IN *SMARAGDIA CHIPOLANA* (GASTROPODA:NERITIDAE)

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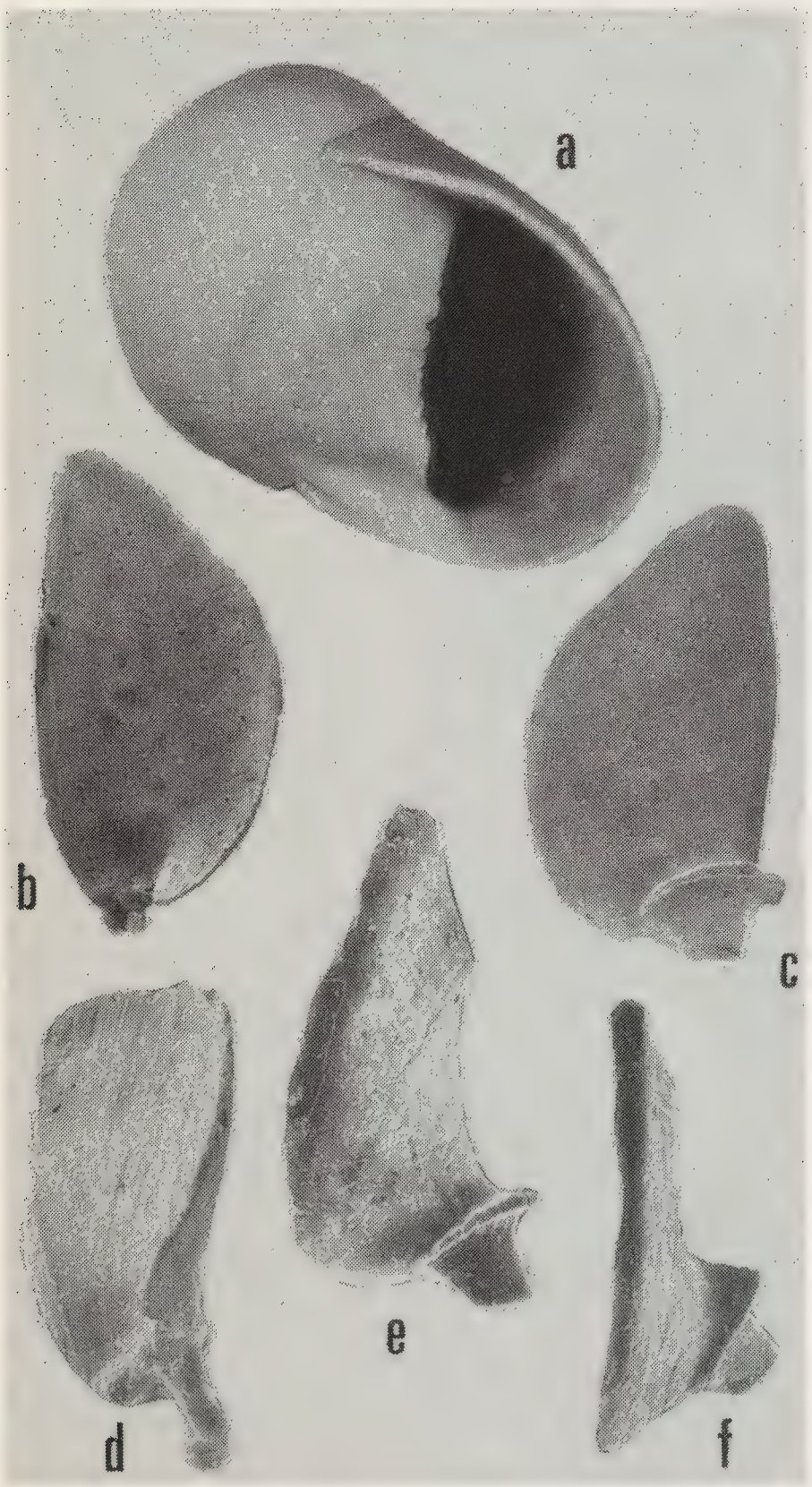
The small neritid gastropod originally named *Neritina chipolana* (Dall, 1892, p. 422, pl. 23, fig. 19) is a common element in the fauna of the Chipola Formation. Although confined to the Chipola Formation it is widespread there, occurring at almost every locality but most abundantly in the lower beds along Tenmile Creek.

In the original description Dall commented upon the most unusual feature of this species (which is, however, characteristic of the Family Neritidae) and that is the amazing degree of variation in the color pattern, stating: "This neat little shell retains its color-markings, which are composed of dark, narrow lines radiating from the axis and over the whorl in every conceivable form of zigzag or curve, either singly or in groups of three to five, either continuous or broken."

Gardner (1947, p. 608, pl. 62, fig. 11 [a copy of Dall]) changed the generic assignment to *Smaragdia,* and added: "This small form is remarkable for the persistence of its color markings, which are curiously sketchy and oriental in design."

The shells are always small, most are about 5 mm in height; the largest specimen seen measures only 7.0 mm in height and 8.0 mm in diameter. The color pattern, as noted, is very persistent, but is limited to a thin outer layer of the shell; decorticated specimens lose the pattern.

The purpose of this note is to document the statements above and to call to the attention of the reader the beauty of these tiny works of art, which do look much as though they were decorated by an oriental calligrapher.



Text-figure 1. *Smaragdia chipolana* (Dall); USNM 450385; height 5.5 mm, diameter 6.5 mm; locality TU 546. A, Apertural view (X 7); B-F, operculum (X 15; B, outside; C, inside; D-F, lateral views); SEM photographs by David G. Robinson, Tulane University.

LITERATURE CITED

DALL, W. H., 1892, Contributions to the Tertiary fauna of Florida: Wagner Free Inst. Sci., Trans., v. 3, pt. 2, p. 201-473, pls. 13-22, 1 map.

GARDNER, JULIA, 1947, The molluscan fauna of the Alum Bluff Group of Florida: U. S. Geol. Surv., Prof. Paper 142-H, p. 493-656, pls. 52-62.

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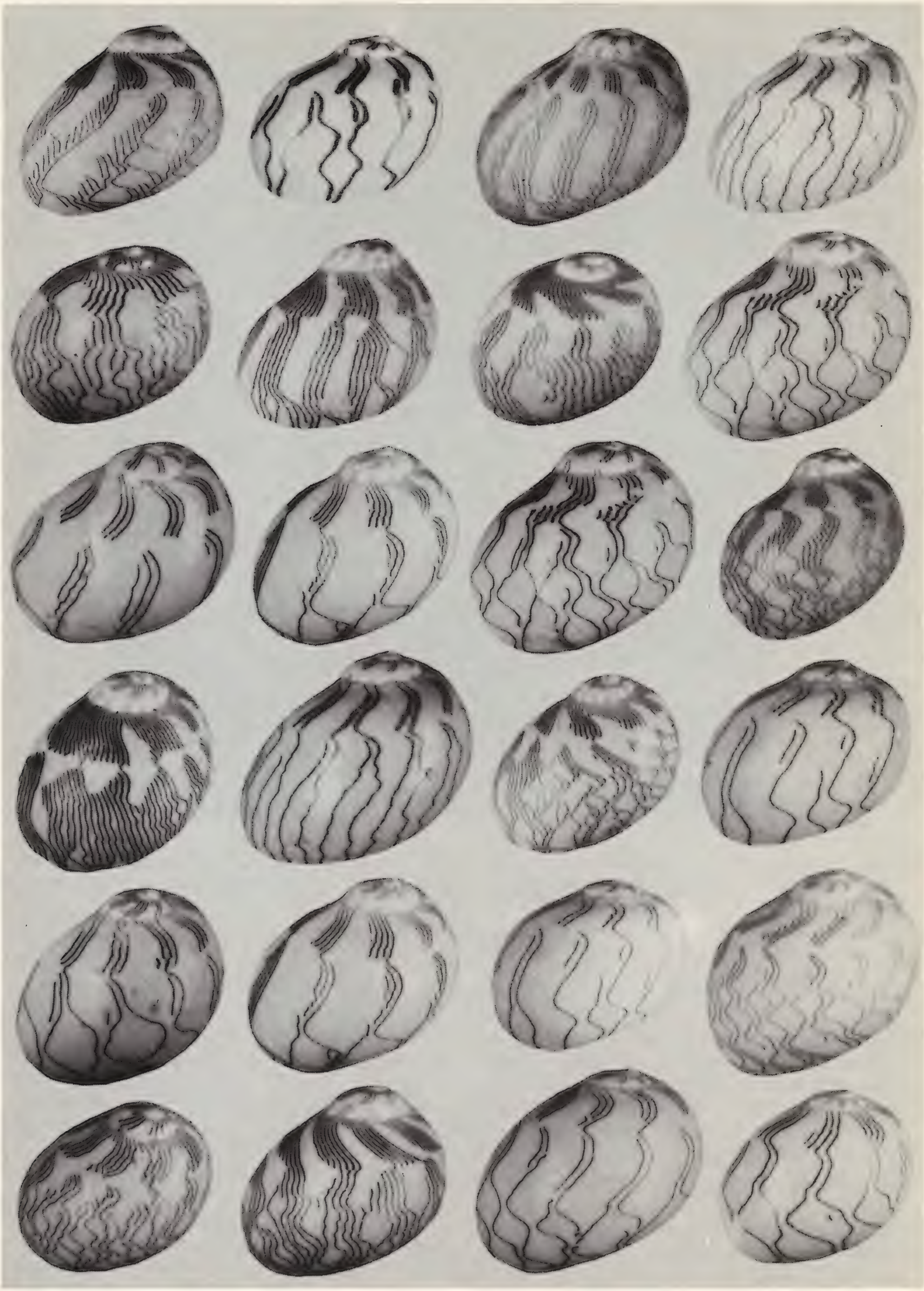
Text-figure 2. Color patterns in *Smaragdia chipolana* (Dall). All specimens from locality TU 546, Tenmile Creek, one and one-half miles west of Chipola River, Calhoun County, Florida.



VIGNETTES OF COASTAL PLAIN GEOLOGY

WALTER SCOTT ADKINS
(1890-1956)

Walter "Doc" Adkins trained as a biologist and his first professional position was as an Assistant Professor of Biology at Texas Christian University. Here he was attracted to the fossils of the northern Texas Cretaceous. In 1919 he joined the staff of the Bureau of Economic Geology, University of Texas, and from that time he devoted his life to the study of the stratigraphy and paleontology of the Mesozoic of Texas and Mexico, culminating in his masterful study on *The Mesozoic Systems in Texas* (1933). In 1934 he went to work for Shell Oil Company and much of his professional life was spent with Shell, or its Mexican subsidiary "El Aquilar," where his greatest contribution was the inspiring and training of younger geologists. Upon his death, the extensive fossil collections he had amassed over his lifetime were deposited in the Department of Geology, University of Texas, where they are available for all workers. Described as "lovable, generous, cantakerous, and argumentative," he was an unforgettable character and a legendary figure among Texas geologists. (*From* J. T. Lonsdale, 1957, Geological Society of America, Proceedings for 1956)

NOTES ON THE FAUNA OF THE MOÍN FORMATION – I ON THE OCCURRENCE OF *GYRINEUM* IN THE EARLY PLEISTOCENE MOÍN FORMATION OF COSTA RICA

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This is the first of a series of papers concerning the molluscan fauna of the Moín Formation. The Moín Formation, also known in the literature as the Moen Beds (Gabb, 1881), Limón Formation (Olsson, 1922), or variations thereof, is exposed at various points on the Limón Peninsula, on the Caribbean coast of Costa Rica. Its geology and micropaleontology have been dealt with in detail by Cassell (1986), but the macrofauna has been studied only in terms of a few individual species as parts of larger taxonomic works.

All outcrops of the Moín Formation occur in the Limón Peninsula, where they are briefly exposed by the clearing of the tropical forest and subsequent bulldozing. This is followed by the building of residential developments of the encroaching town of Puerto Limón. The greatest measured section represents some 70 meters of blue clay, with horizons of mixed clay and coral rubble (Cassell, 1986). The depositional depth may vary with each outcrop, but in general lies between approximately 100 and 300 m, based on the contained molluscan and foraminiferan faunas. The formation contains molluscs from a wide variety of habitats, from intertidal to middle shelf, the shallower water material having fallen downslope to below the base of the reef. Exposures often include large sections of coral, representing accumulations of coral rubble, as well as large blocks of the fore-reef itself, that slid down to their final depositional depths.

The lower outcrops of the Moín Formation have been dated as early Pleistocene (Akers, 1972), and the higher exposures extend well into the middle Pleistocene. These outcrops contain one of the richest Pleistocene fossil molluscan faunas in the Caribbean Basin. In addition to a predominantly Recent aspect, the Moín fauna also contains significant regional and/or temporal endemic components, as well as West African, Paciphile, and other seemingly anomalous elements. Among the latter is the occurrence of *Gyrineum louisae* Lewis, 1974.

Gyrineum louisae was first illustrated as an unidentified shell "resembling a *Bursa*" collected during the *Pele II* expedition (Burgess, 1963). It was dredged at a depth of 180 fm (=329 m) off Pokai Bay, Oahu, Hawaii, and it was eventually described by Lewis (1974), who recognized it as a *Gyrineum*. Another specimen, collected at a depth of between 314 and 323 m from the Great Meteor Bank in the eastern Atlantic in 1967, was described as *Gyrineum atlanticum* by Fechter (1975), as a sibling (=cognate) species of *G. louisae*. The two were later synonymized by Beu (1985, p. 56).

SYSTEMATICS

Family RANELLIDAE Gray, 1854
Subfamily RANELLINAE Gray, 1854
Genus GYRINEUM Link, 1807
Subgenus GYRINEUM Link, 1807

GYRINEUM (GYRINEUM) LOUISAE Lewis, 1974
Text-figure 1

? *Bursa* sp. BURGESS, 1963, Hawaiian Shell News, vol. 11, no. 8, p. 1.
Gyrineum louisae LEWIS, 1974, Nautilus, vol. 88, no. 1, p. 10, figs. 1-3, 6.
Gyrineum atlanticum FECHTER, 1975, "Meteor" Forsch. Ergebnisse, Ser. D, no. 21, p. 62, figs. 1-3, 7 left fig., 8.
Gyrineum (Gyrineum) louisae Lewis. BEU, 1985, Conch. Amer. Bull., vol. 13, no. 4, p. 56.

Description: "Shell white, 19 mm in length and 12 mm in width at the periphery. There are six whorls producing a spire of 57°. The outer lip is thickened at the final varix. The 9 varices do not align but are slightly offset. There are 13 spiral cords crossed by 16 axial ribs between the varices which form a very fine beaded pattern. The axial ribs do not extend to the varices forming 13 distinct fine ridges on the varix of the outer lip. The siphonal canal is very short, measuring only 1½ mm from the base of the outer lip to the tip of the canal. There is a glossy raised peristome on the inner edge of the outer lip which continues to the upper edge of the glazed parietal wall. The protoconch is covered by a fine network of axial ribs and spiral cords but is similar in shape to other species in the genus. The operculum and animal are unknown." (Lewis, 1974)

Remarks: The only discernible difference between the Moín specimens and their Recent counterparts is that of size, the Pleistocene representatives of the species being about 1¼ times the size of the holotype with the same number of teleoconch whorls. The Atlantic specimen lies intermediate between the two, indicating that this character may indeed be variable, based on the few specimens available for study.

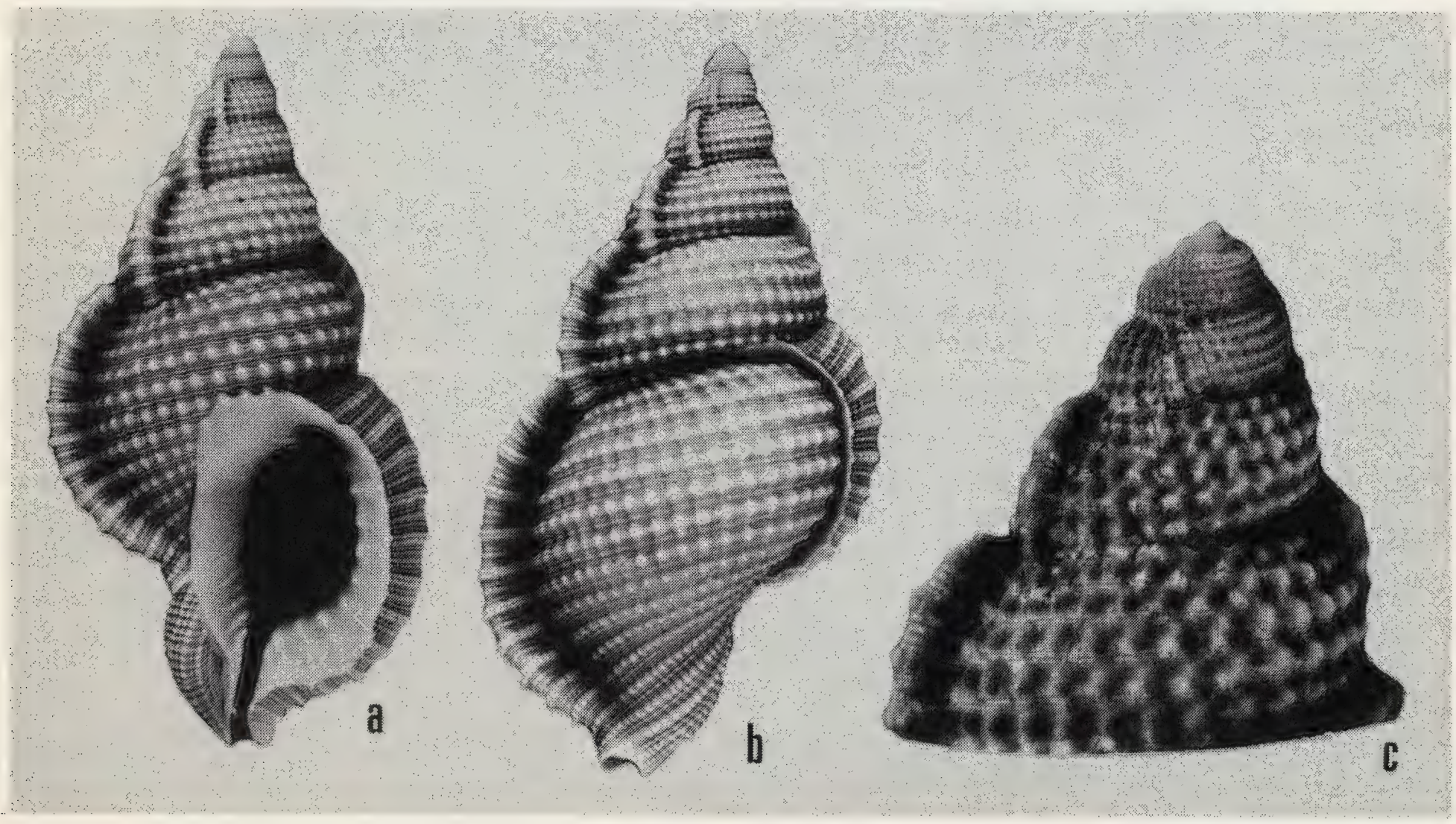
At the present time, the species is represented in the Moín by a single, large, perfectly preserved specimen (text-figure 1), measuring 31.5 mm in length, as well as two other fragments, each representing the last varix of an adult specimen*. All three were collected from Tulane locality TU 1239, which has yielded a molluscan fauna characterized by a preponderance of species occurring today from fore-reef to middle-shelf environments. That both the holotype of *Gyrineum louisae* and of *G. atlanticum* were collected at depths of between 314 and 329 meters, may indicate that the depositional depth at TU 1239 lies within that range.

The species today appears to have a wide geographical if disjunct distribution and its occurrence in the Moín Formation indicates that it was probably living in the Atlantic and eastern Pacific basins prior to the last closure of the Central American Isthmus. Whether *Gyrineum louisae* is still as widely distributed but living at considerable depths, or survives in isolated spots in the Atlantic and Pacific Oceans, is yet to be ascertained.

*While this paper was in press, Alan G. Beu (*in litt.*), New Zealand Geological Survey, reported that a specimen of *Gyrineum louisae* was in his possession, collected by Drs. Harold Vokes and Emily Vokes from locality TU 1240 several years previously. This locality is the hilltop on Calle King Fish in Barrio Los Corales 2, 1.4 km north of the Standard Fruit Company's box factory at Pueblo Nuevo, 2 km west of Puerto Limón. Locality TU 1240 represents a depositional environment similar to TU 1239.

ACKNOWLEDGMENTS

The writer is indebted to Dr. Emily H. Vokes of Tulane University for her support and encouragement while he was working on this project. Grateful thanks are also extended to two field assistants, Richard J. Kirshner of New Orleans, Louisiana, and Dr. J. Michel Montoya of San José, Costa Rica, who helped collect numerous molluscan specimens from TU 1239 over two field seasons.



Text-figure 1. *Gyrineum (Gyrineum) louisae* Lewis; USNM 416234; length 31.5 mm, diameter 16.5 mm; locality TU 1239, Moín Formation, Costa Rica. (Figs. 1a, 1b, X 2; fig. 1c, X3).

LOCALITY DATA

1239. Moín Formation, hill above Standard Fruit Company's box factory in Barrio Los Corales 1, about 2 km west of Puerto Limón, Costa Rica.

LITERATURE CITED

AKERS, W.H., 1972, Planktonic foraminifera and biostratigraphy of some Neogene formations, northern Florida and the Atlantic coastal plain: Tulane Stud. Geol. Paleont., vol. 9, nos. 1-4, p. 1-139, pls. 1-60, 4 figs., 1 map.

BEU, A.G., 1985, A classification and catalogue of living world Ranellidae (= Cymatiidae) and Bursidae: Conch. Amer. Bull., vol. 13, no. 4, p. 55–66, figs. 1-55.

BURGESS, C.M., 1963, Undetermined species dredged by *Pele II* (from the *Pele II* log): Hawaiian Shell News, vol. 11, no. 8, p. 1, figs. 1, 2.

CASSELL, D.T., 1986, Neogene Foraminifera of the Limón Basin of Costa Rica (Ph.D. dissert., LSU, unpub.).

FECHTER, R., 1975, *Gyrineum atlanticum* sp. nov., eine Zwillingsart (sibling species) des bisher nur von Hawaii bekannten *Gyrineum louisae* Lewis (Gastropoda/Prosobranchia; Cymatiidae): "Meteor" Forsch.-Ergebnisse, Ser. D, no. 21, p. 62-66, figs. 1-9.

GABB, W.M., 1881, Description of new species of fossils from the Pliocene Clay Beds between Limon and Moen, Costa Rica, together with notes on previously known species from there and elsewhere in the Caribbean area: Acad. Nat. Sci. Phila., Jour., (Ser. 2) vol. 8, no. 4, p. 349-380, pls. 45-47.

LEWIS, H., 1974, A new species of Hawaiian *Gyrineum* (Cymatiidae): Nautilus, vol. 88, no. 1, p. 10-13, figs. 1-11.

OLSSON, A.A., 1922, The Miocene of northern Costa Rica, with notes on its general stratigraphic relations: Bulls. Amer. Paleont., vol. 9, no. 39, p. 7-288 (179-460), pls. 1-32 (4-35).

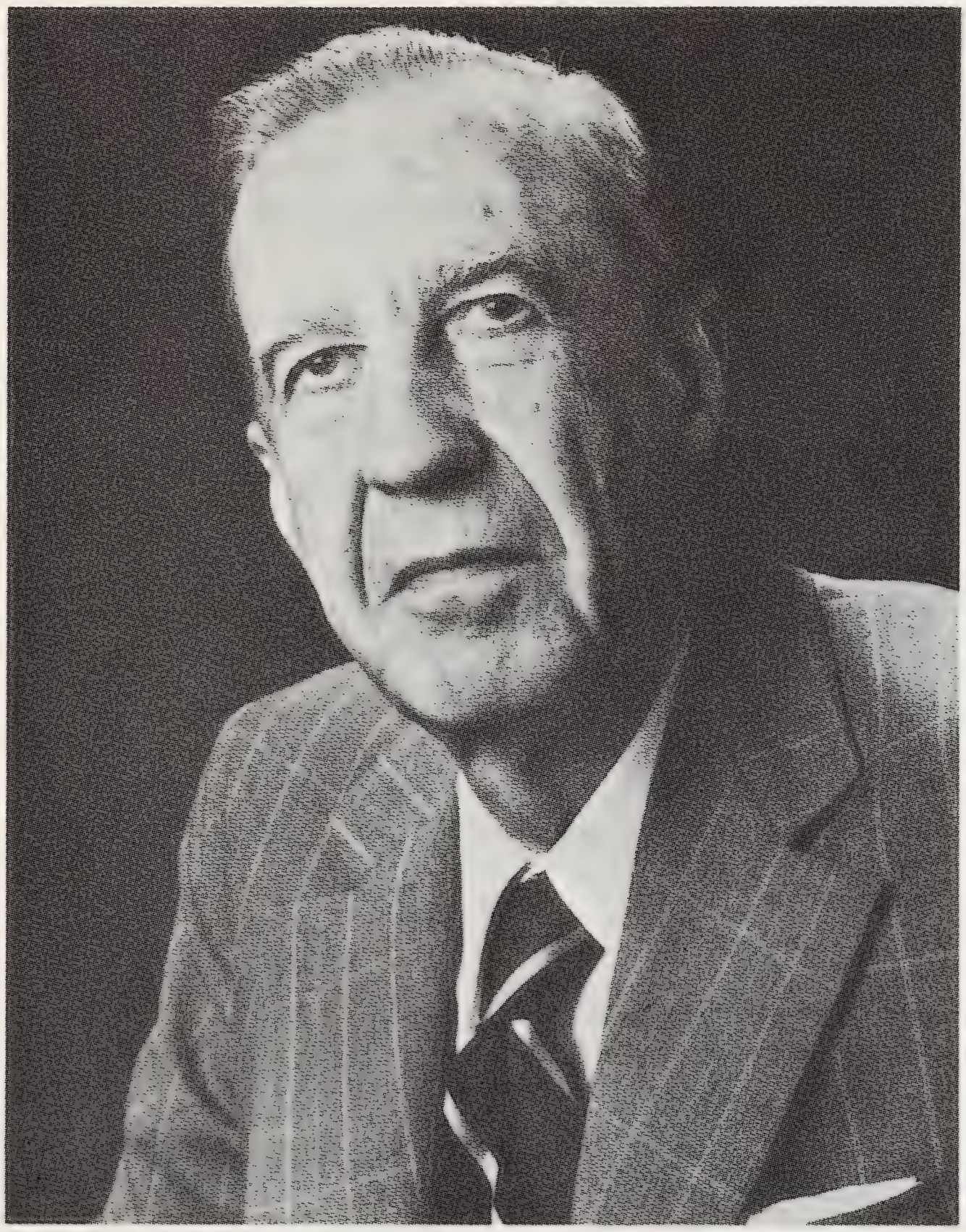
December 12, 1990

REVIEW

MARINE MICROPALEONTOLOGY OF CHINA, by Wang Pinxian *et al.* Published by China Ocean Press, Beijing, China, and distributed by Springer-Verlag, Berlin, Heidelberg, New York, and Tokyo, 1985, x + 370 pp., illus., atlas of 38 pls., $85.00

This volume contains seventeen papers by thirteen authors dealing with the distribution patterns of Foraminiferida and Ostracoda and the evolutionary history of the shelf seas off China. Most of these papers were published (in Chinese) in Papers of Marine Micropaleontology (1980), but are here considerably revised and supplemented as well as translated into English; some are new. These articles cover a broad spectrum of micropaleontological groups including foraminifers, ostracods, and calcareous nannoplankton from the Tertiary to the present and represent systematic sampling and micropaleontological analyses of bottom sediments of the East China Sea, the Huanghai Sea, the South China Sea, and the Bohai Gulf (thus, all the shelf seas off China). The studies are both qualitative and quantitative, permitting paleoenvironmental reconstructions. One paper summarizes the microfaunas from seven Chinese estuaries, compares them with estuarine microfaunas from other parts of the world, and points out their geological significance and relationship to oil-bearing sequences. Another deals with living foraminifers and ostracods in the marginal areas of the Huanghai and East China seas and reveals salinity control of the species and assemblage distributions. Other papers are concerned with bore-hole samples and the interrelationships of sea-level changes and transgression/regression cycles in the late Quaternary. Though these papers do not fully cover the extent and variety of micropaleontological research in China, they do present much insight into the present knowledge of this most important area.

—H.C.S.



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A native of Mobile, Alabama, from early childhood Lyman Toulmin exhibited a keen interest in the natural history of the area. After receiving degrees from the University of Alabama and Princeton University, he taught at Texas A & M and Birmingham Southern Universities, and worked briefly for the Alabama Geological Survey. In 1948 he moved to Florida State University, Tallahassee, where he remained the rest of his life. He was a dedicated field worker, contributing much to our knowledge of the Geology, Stratigraphy, and Paleontology of the Gulf Coastal Plain. A monograph on *The Stratigraphic Distribution of Paleocene and Eocene Fossils in the Eastern Gulf Coastal Region* (1977, Alabama Geol. Surv., Mon. 13), including 72 plates of fossils, will remain as a testament to his years of study. (*From* P. E. LaMoreaux, 1985, Gulf Coast Association of Geological Societies, Transactions, v. 35)

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